SCIENCE LIBRARY 182

MAR 12 1931

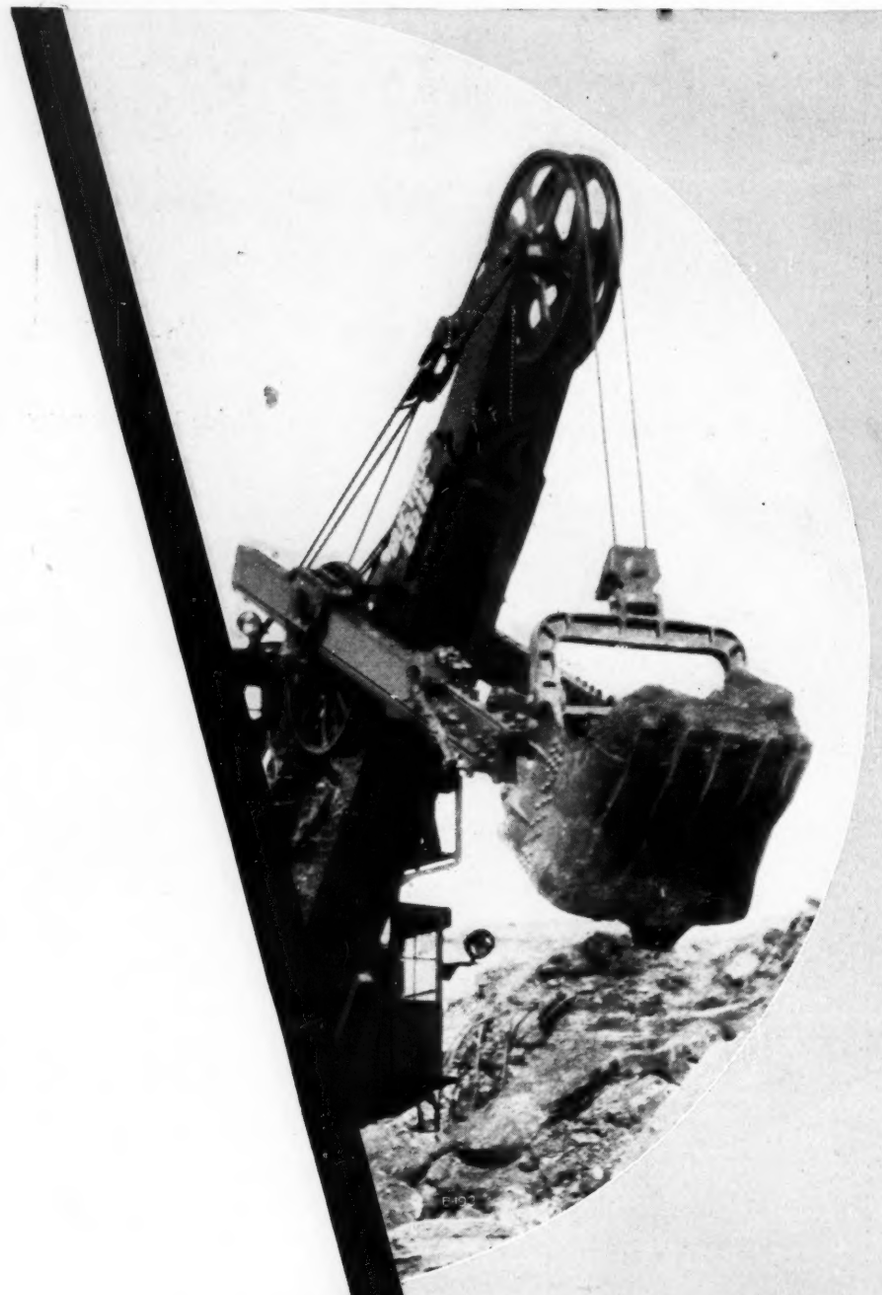
Engineering and Mining Journal

A McGraw-Hill Publication

Price 25c. per copy

Man and machine at work in an open-pit copper mine

March 9, 1931



The quarry or mine that uses Bucyrus-Eries increases production, cuts operating costs, repair bills and delays because of the strength, reduced dead weight, and longer upper boom section of this front end. Write for bulletin on size you need.

BUCYRUS-ERIE COMPANY

South Milwaukee, Wis., Offices or distributors in principal cities.

BUCYRUS ERIE

A-256

Associate Editors
E. H. ROBIE, A. H. HUBBELL

Assistant Editors
W. N. P. REED, H. D. KEISER
S. D. STRAUSS, B. H STROM

Market Editor
H. H. WANDERS

Engineering and Mining Journal

A. W. ALLEN, *Editor*

San Francisco
GEORGE J. YOUNG
Associate Editor

Tucson, Ariz.
JOHN B. HUTTL
Assistant Editor

Publishing Director: H. W. CLARKE
New York

Contents for March 9, 1931

Contents Copyright 1931 by McGraw-Hill Publishing Company, Inc.

VOLUME 131 . . . NUMBER 5

Editorials 203

Future Planning Must Be Based on Sound Principles . . . . "Buy Now" Also Applies to Research . . . . Geology of the Yosemite Valley . . . . Technique on Non-Submergence Leaching . . . . . Technical Sessions at Institute Meetings. . . . An All-Metal House—A Future Possibility

Limestone Transportation ..... *Charles K. Traber* 206

Vermont Copper District ..... *C. S. Anderson* 208

Pre-Cambrian Conceptions ..... *Arnold and Robert D. Hoffman* 211

The Sullivan Mine ..... *George J. Young* 215

Internal Combustion Engines, I ..... *A. H. Hubbell* 218

Drift Curves ..... *George A. Clayberg* 221

Open-Stope Mining ..... *Morris J. Elsing* 223

Fire-Refining Copper ..... *H. H. Alexander* 226

Dilution and Depletion ..... *W. Earl Greenough* 230

Book Reviews 231
Personals, Comment, Criticism 232
Industrial Progress 233
News of the Industry 236
Cabled News 241
Market and Financial News 243
Mining Share Prices 250
Professional Directory 48
Searchlight Section 49
Advertising Index 52

McGraw-Hill Publishing Company, Inc.
Tenth Avenue at 36th Street
New York, U. S. A.
Cable Address: "Machinist, N. Y."

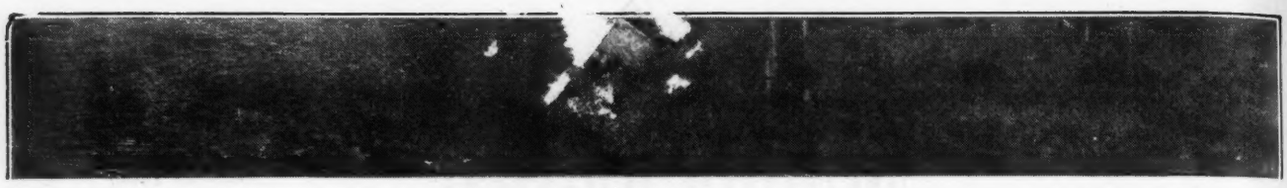
JAMES H. McGRAW, Chairman of the Board
MALCOLM MUIR, President
JAMES H. McGRAW, JR., Vice-Pres. and Treas.
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
HAROLD W. McGRAW, Vice-President
H. C. PARMELEE, Editorial Director
C. H. THOMPSON, Secretary

Published semi-monthly. Price in the United States and possessions, 25 cents (U. S. Currency) per copy; $4 per year. In all other countries, $20 per year—24 issues. Entered as second-class matter, June 20, 1879, at the Post Office, New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A.

Member A.B.P. *Member A.B.C.*

7,600 COPIES PRINTED THIS ISSUE

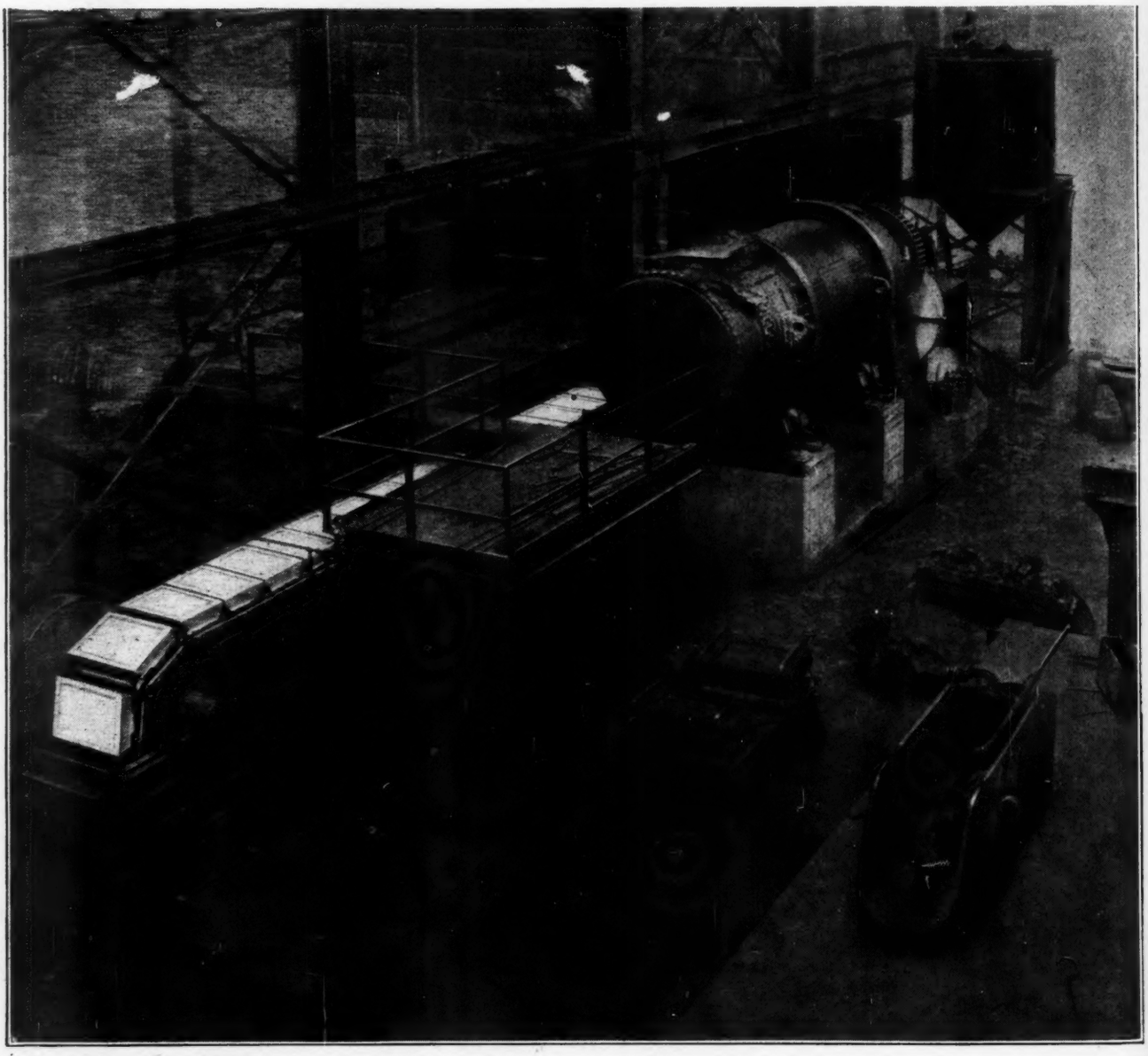
NEW YORK District Office, 285 Madison Ave.
WASHINGTON, National Press Building
CHICAGO, 520 N. Michigan Ave.
PHILADELPHIA, 1600 Arch Street
CLEVELAND, 501 Guardian Building
ST. LOUIS, 1556 Bell Telephone Building
SAN FRANCISCO, 883 Mission Street
BOSTON, 1427 Statler Bldg.
GREENVILLE, S. C., 1301 Woodside Bldg.
DETROIT, 2-257 General Motors Bldg.
LOS ANGELES, 632 Chamber of Commerce Bldg.
ENGLAND, 6 Bouverie St., London, E. C. 4



Casting Machines

Casting Machines of both the circular and straight line types are built by Allis-Chalmers. One type of straight line machine is shown here, in a copper converting plant. It is used in connection with an Allis-Chalmers revolving copper holding furnace.

When you build a new plant or modernize the old one remember that Allis-Chalmers can supply all of the principal equipment needed.



ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

Engineering and Mining Journal

March 9, 1931 A. W. ALLEN, *Editor* Vol. 131—No. 5

Future Planning Must Be Based On Sound Principles

A SUPPLEMENT to this issue of *Engineering and Mining Journal* embodies in modified form the recommendations made by Dr. Virgil Jordan, economist to *The Business Week*, in an address delivered before the Railway Business Association, in New York, on November 10, 1930, on the subject "The Next Five Years: A Challenge to Business Leadership." The statement of underlying principles in the platform now proposed merits careful analysis and study, and the suggestions made are deserving of individual consideration and co-operative action. Of particular significance to the mining industries is the recommendation that planning be projected on the long-term basis so essential to uninterrupted progress. Pleas for the maintenance of high living standards—physical, mental, and moral—will meet with the hearty endorsement of the leaders of the mining industry, who have provided ample evidence of their concern for the welfare of employees—a characteristic of progressive thinking and an evidence of a desire to create and cement satisfactory industrial relations. The industry recognizes that it lives and functions somewhat apart from the current of American business, and that the isolation, actual and comparative, of so many mining properties calls for a more direct consideration of factors that affect the health and comfort of the community than is demanded of the management of general and urban industrial enterprises.

Unfortunately, as was pointed out in these columns at the peak of the last boom, the prosperity then in evidence in the United States was being shared by the worthy and the unworthy. Business was being accelerated by an abnormal standard of expenditure among a large cross-section of the population, whereas few citizens among the masses that provide the greatest stabilizing influence on business escaped the direct or indirect payment of tribute to an extensive system of social and business intimidation. A mixture of good and bad elements benefited from the prosperity of the period, but contempt for authority and discipline became so widespread that the administration of justice collapsed under the strain; and confidence in the ability and prescience of the directors of the nation's destinies in economic and financial matters has been rudely shaken by sundry unfortunate happenings, and the exposures that are developing.

Mining, unlike most other businesses in the United States, has problems peculiar to its own environment. Its ability to advance without interruption would not be enhanced by overindulgence in most of the major expenditures or the social diversions of urban life. Encouragement of abnormal personal expenditures, with attendant tribute to a highly organized underworld and its legal protectors, is not a part of its program for the future. It differs from most other industries in that its expansion depends on the avoidance of waste rather than on the encouragement of waste. Equipment used for extraction and beneficiation and manufacture, and the ultimate products themselves, are typical of long life, if not permanence. The users of metals, as well as the producers of metals, are imbued with the advantages of economical management—the dictionary definition of "thrift." The industry looks forward to an era of temperate acquisition and temperate expenditure, of stability in prices, and of security of employment tenure for the individual. This can best be assured by adequate and long-term planning.

Recommendation that increased attention be paid to industrial associations is particularly timely. Obvious good has resulted from the establishment of the American Bureau of Metal Statistics, the Copper and Brass Research Association, the Lead Industries Association, the American Zinc Institute—to mention but a few of the many agencies that are helping to stabilize commerce to the benefit of all concerned. To prevent depressions that are the concomitants of industrial inaction, however, business leaders must minimize peaks that are indicative of industrial overproduction—the outcome for the most part of unbridled price competition that merely enervates the contestants. The success of stabilizing plans will depend to a considerable extent on freedom from government insistence that this type of industrial warfare shall continue. In this connection the necessity is obvious to stress the hazard of neglect to make special provisions that take into account the unusual occupational characteristics of mining, calling for heavy expenditures that cannot be met so long as a national policy of price-cutting is carried to the bitter limit, a policy that takes no consideration of the variability in degrees of responsibility in each industry toward the human element.

No proposals for economic rehabilitation can hope to provide a panacea for all industrial ills. But the platform now presented will achieve much if it leads to the encouragement of individual thought, the elimination of the impracticable, and the acceptance of what is obviously sound economic and social doctrine. To plan ahead —the most important recommendation—is to crystallize into definite form that which is best for industry and for the country as a whole. The strength of a chain is the strength of a single link, however. National progress cannot be made unless the individual bears a proportion, at least, of responsibility for his own future well-being, indicated by personal initiative as well as co-operation with industry in assuring uninterrupted contribution to the stream of commercial life, in the form of regular purchases for the maintenance of physical and mental

standards. Long-term planning—in regard to output, income, and expenditure—is as necessary for the individual as it is for a commercial enterprise. Thus will the individual learn to pattern his affairs from the principles and policies of a well-conducted business, thereby contributing materially to national stability and steady progress. The industrial, social, and political fabric cannot be more sound and healthy than are its component parts.

"Buy Now" Also Applies to Research

LESSONS gained by adversity usually furnish the basis for reformed practice. Industry must realize that the year 1930 produced a new type of buyer, who exercises great discrimination in his scrutiny of merchandise, and who possesses a keen sense of values. This tendency encourages the application of a scientific economy in production, which undoubtedly will be reflected in most industrial budgets for 1931. A hazard exists, however, that instructions to reduce operating expenses are likely to apply in most instances to research and development work, the temptation to restrict which is all the greater because returns are not always directly traceable in the profit statement.

But farsighted leaders of industry will refuse to push research into the background. They realize that opportunities for the development of new sources of revenue should be kept open at all times, especially when earnings are on the decline. Speaking before the Canadian Institute of Mining and Metallurgy, Mr. John L. Agnew, vice-president of International Nickel, recently made the statement that his company had increased appropriations for research on the uses of nickel by one-third, despite the inactivity now prevailing in the industry. This decision expresses appreciation of the work of a research staff that has been so successful in developing peacetime uses for nickel—essentially a war metal a few years ago. Public statement of such a decision is to be commended. It is a challenge to leaders of other metal-producing industries to investigate neglected opportunities for expansion.

Geology of the Yosemite Valley

THE Yosemite Valley of California is a natural scenic resource that provides a revenue to the people of the state that is probably many times greater than that derived from most gold mines. Its geology has long been a subject of discussion. Layman and specialist have each contributed, but the subject upon which most doubt arose was whether the spectacular gorge of the Yosemite was the product of glacial erosion or of stream erosion.

J. D. Whitney believed in the catastrophic cause of origin. One of his younger assistants, Clarence King, likewise believed in this theory; John Muir advocated the glacier theory; Joseph Le Conte recognized the trail of the glacier, but attributed a share of the excavation to stream action prior to the coming of the glacier; Henry W. Turner pointed out that stream erosion and weathering were largely responsible; and Andrew C. Lawson believed that the Yosemite had been elaborated by glaciation from a profound erosional gorge. More recently, the United States Geological Survey has published a monograph by Francois E. Matthes, aiming to give an accurate geological history of this small area, based upon careful field studies. Several cycles of stream erosion are believed to have been followed by the molding and cutting of the glaciers. The depth excavated by glaciers is estimated to range from 500 to 1,500 feet. The widening produced by the glacier ranged from 600 to 1,800 feet on each side of the valley. Post-glacial changes, such as the filling of the glacial basins with sediments, have since taken place. Thus, a complete and interesting account has been evolved.

Although the mystery of the origin of Yosemite has been authoritatively decided, the fact will not detract from the enjoyment of this scenic gorge by thousands of visitors, most of whom, concerned not at all with geology, are eager to see its great walls and shimmering cataracts, and to enjoy its trees and flowers as John Muir once did.

Technique of Non-submergence Leaching

RESEARCH on the recovery of soluble material from a colloidal gangue was concluded recently by Messrs. J. D. Sullivan and A. P. Towne, both of the technical staff of the United States Bureau of Mines, the results being available in bulletin form. Recovery of copper from slime tailing seems to have been achieved successfully and economically by agglomerating the material with sand and water (or leach solution) in a revolving mixer. The glomerules resulting—mostly varying in diameter and size from one-half inch to 28 mesh—are then treated in a vat by trickle percolation, similar to the method employed in heap leaching. Experimental results on a charge containing thirty per cent of minus 200-mesh material indicated an extraction of eighty per cent of the copper in sixteen days, with effluent solution of a clarity and copper concentration suitable for electrolytic precipitation.

Opportunity may be seen for a trial of the new method with other types of raw material, but attention must be drawn to the hazard of a mistaken inference that a mass is necessarily untreatable by the quicker process of submergence leaching if short circuiting of solution occurs. In many instances this channeling of the lixiviant is the result of an uneven distribution of slime in the charge, generally caused by filling the vat from a height, a method that invites segregation. A layer of oversize in the bottom of the leaching vat—a concomitant to this method of filling—is rarely desirable. It serves no useful purpose as a filter medium, at a point where clarification should not be a problem, and its segregation robs the charge of a proportion of the total available amount of crystalline material so essential as a filter aid.

When the fundamental requirements of successful bulk leaching are disregarded, the slime present is invariably blamed for poor results, or accepted as precluding utilization of the process. This was particularly the attitude in the Chilean nitrate industry before the successful bulk treatment of refractory *caliche* demonstrated that a high-slime material could be leached successfully by simple and inexpensive methods, without the segregation and separate treatment of fines. A proposal outlined in a United States patent of 1930—that the grab bucket used for discharging residue should also be used for filling the leaching vat, from an open bin of crushed ore alongside—insures the avoidance of a segregation of coarse from fine that is the usual sequel to ordinary methods of filling, with resultant short-circuiting of solution and faulty extraction.

With some metallic ores suitable for leaching in a raw condition, however, comminution must be carried so far, or the natural slime is present in so great an amount that bulk leaching, even after ideal distribution of the charge, is impracticable. In such instances, whether the solvent be acid or cyanide or water, the process under development by the United States Bureau of Mines—non-submergence leaching of glomerules of slime and crystalline gangue—is worthy of consideration and trial.

Technical Sessions
At Institute Meetings

AFTER every A.I.M.E. convention—and our remarks apply to the meetings of other societies as well—we cannot help cogitating upon the misuse of time at the technical sessions. Ordinarily, the papers to be presented are available in printed form, and have been so available for weeks. Anyone who is particularly interested has had the opportunity to see them before the meeting. Why, then, allow the author, or his representative, to take up valuable time in reading the paper, or in making a tiresome extemporaneous abstract, and then, as a result, be obliged to limit the discussion? Why not make a rule that one who presents a printed paper shall not take more than five minutes in so doing, unless he has original material to offer that is not incorporated in the paper? The time so saved can be used profitably for discussion.

Another improvement would add greatly to the comfort and mental alertness of those who attend technical sessions, and also those who listen to after-dinner speeches. Cannot someone be made responsible for proper ventilation of the room in which such meetings are held? When the temperature passes a desirable maximum, cannot some arrangement be made whereby the steam radiators shall cease functioning as such? When will those in control realize that a crowd is a heating plant in itself, that uniformity of temperature and bearable conditions can be maintained only by a gradual reduction in the provision of artificial heat, in proportion to the size of the crowd? No better cure for insomnia exists than the usual room in which fifty or a hundred people have been herded for an hour or so, particularly if the discussion is more or less theoretical. Are we engineers or are we mice?

An All-Metal House—
A Future Possibility

COST of home building has shown only a slight inclination to recede with falling prices of commodities. Shelter, the largest single item of expense in the budget of the average wage earner, is remaining high for two principal reasons—high value of land in or near the cities, and costly and inefficient methods of construction. But need these conditions always be unfavorable? Improved means of transportation have already started an exodus from the cities. As this progress continues, man may soon be able to follow his natural instinct and again become a rural dweller. Land sufficiently low in price will again be within his reach, and only the barrier of high building cost will prevent him from attaining a desire to own his own home.

Improved methods of transportation, which have imparted this greater mobility to man, have created many new uses for metals. Far greater, however, are the possibilities of profit to the metal industry in the field of home building. For many years a strong campaign has been conducted to increase the use of non-ferrous metals in the home, a campaign that has born rich fruit; but, unfortunately, these efforts have been restricted to auxiliary uses, such as furnishing, fittings, and roofing. Little attention has been given to the possibility of using metal as the chief material of construction, a field offering the most alluring prospects. A few straws in the wind are indicating, however, that a change in this respect is taking place. The January issue of the bulletin of the Copper and Brass Research Association contains the interesting information that houses are now being built in Germany with rolled copper sheet exteriors. The interior is of steel, with suitable insulation. Such a unit, manufactured at low cost, is readily shipped, and can be assembled with ease. Of further interest is the fact that this material permits the execution of many new ideas in construction that are not practicable with the less flexible materials now in common use.

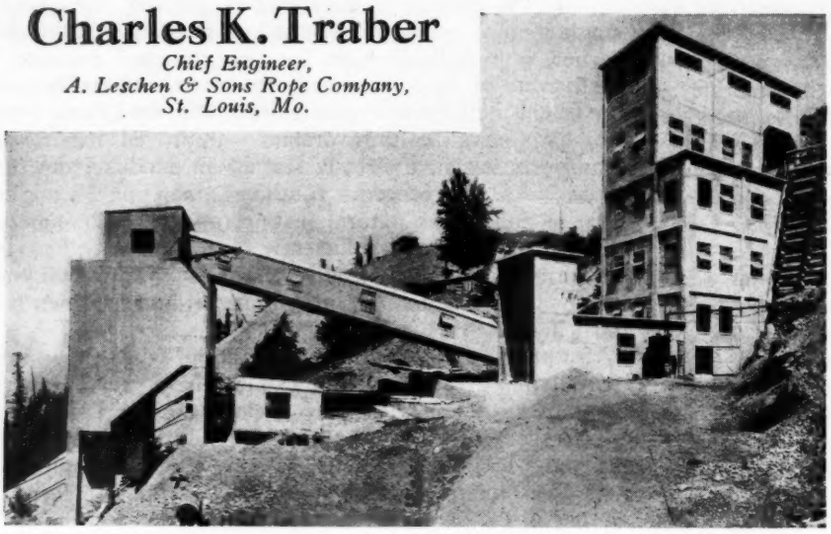
Only a few fundamental changes have been made in the construction of dwellings during many generations. Departure from old ideas and standards may result in improvements of far-reaching effect, in matters of convenience, beauty, comfort, and sanitary conditions. To those who would take advantage of this opportunity the recommendation may be made that imitation and camouflage should be avoided. New types should be developed, whereby the qualities and appearance of the metal are utilized to the fullest extent. A program of education will be necessary. The best advice of architects and builders must be sought.

Discernment or even anticipation of a need is not sufficient. Those concerned must be made conscious of their own need, and in no better way can this be done than by placing the desired object within their reach. Mr. Henry Ford, by his successful career, has plainly demonstrated the truth of this statement. A need for inexpensive, attractive, and practical dwellings exists. To those who are able to take advantage of the situation, who can shape the desire to serve their own end, a substantial reward for themselves and their industry is awaiting.

Limestone Transportation

Charles K. Traber
Chief Engineer,
A. Leschen & Sons Rope Company,
St. Louis, Mo.

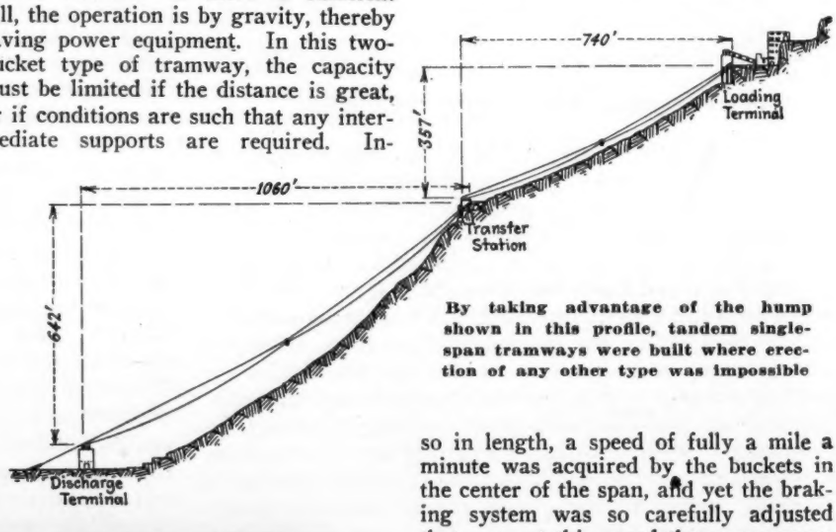
Capacity and economy secured by adoption of duplicate single-span two-bucket rope tramways for conveyance of ore from quarry to railroad



Crusher house and conveyor that carries crushed limestone to the tramway loading bin

WIRE-ROPE tramways for the transportation of crushed stone have been used generally and successfully. Where the distance between terminal points is considerable, and whether the capacity is large or small, a continuous system must be used; that is, a system where several carriers spaced equally travel continuously around the circuit, receiving their load at one end and delivering it at the other. It is a system of comparatively small individual loads spaced close together, approaching the system where the loads are actually merged into each other, as in the operation of a belt conveyor.

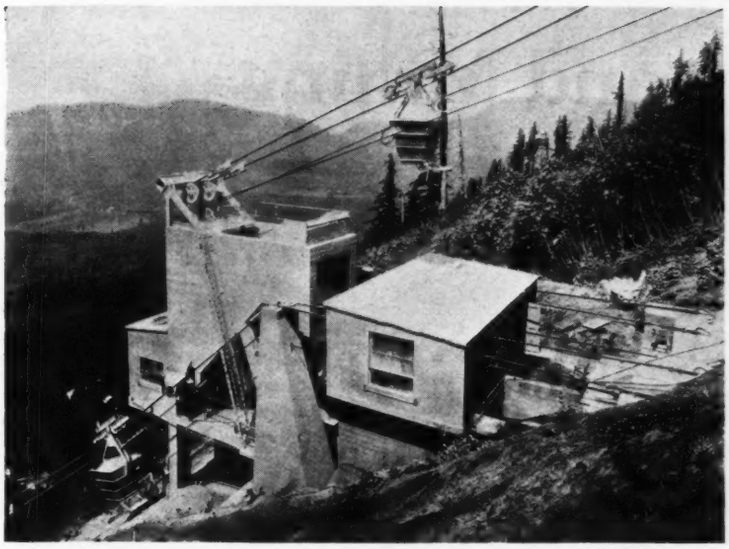
Another form of wire-rope tramway can be economically used if the distance between terminals is short, or if the tonnage is small. This is the oscillating two-bucket type. The loaded bucket proceeds in one direction as the empty bucket returns. If there is sufficient fall, the operation is by gravity, thereby saving power equipment. In this two-bucket type of tramway, the capacity must be limited if the distance is great, or if conditions are such that any intermediate supports are required. Intermediate supports for the track cable necessitate a much slower speed, thereby limiting capacity. It is always desirable, in this type of wire-rope tramway, if the tonnage is large, to make the distance between terminals in a single span. Under these conditions large amounts can be handled—up to 200 tons, and even more, per hour. The speed in such installations is almost unlimited. Observations indicate that in some of these single-span tramways, only 1,500 ft. or so in length, a speed of fully a mile a minute was acquired by the buckets in the center of the span, and yet the braking system was so carefully adjusted that even at this speed there was never any fear, with a reasonably careful operator, that the buckets would get out of control.



By taking advantage of the hump shown in this profile, tandem single-span tramways were built where erection of any other type was impossible

The discharge terminal is built on top of a large storage silo, from which railroad cars are loaded

At the plant of the Olympic Portland Cement Company, the limestone quarry is situated near the top of a mountain range 30 miles northeast of Bellingham, Wash., about 1,000 ft. above the floor of the valley, where the switch connecting with the Chicago, Milwaukee & St. Paul Railroad is located, and about 1,800 ft. distant in a horizontal direction. This distance would not have precluded the use of a single-span two-bucket gravity tramway, as described in the foregoing, had the contour of the ground been favorable. The profile, however, disclosed a decided hump approximately one-third of the way down, which would interfere with the cable of



Intermediate station where limestone from the upper tramway is dumped into the transfer bin and reloaded onto the lower tramway

a single span of conveyor cableway.

Studying the situation, the engineer might perhaps at first conclude that a continuous system, where intermediate supports are not objectionable, would be clearly indicated, inasmuch as the required capacity of 150 tons per hour is not unusual in such a system. However, serious objections arose. In any continuous system the carriers must be brought to a horizontal rail for loading and discharging. This would have meant, in the operation here under consideration, a long approach structure for the terminal, at the upper and at the lower end, because the difference in elevation, together with the large capacity, would produce a heavy stress in the traction rope. In bringing the traction rope from the grade to the horizontal, it would have to pass over many rollers, spaced in such a way as to limit the pressure on each. This long approach would also have been necessary to limit the down-pressure on the carrier as it was passing from the grade to the horizontal. The cost when estimated with these facts in mind was high indeed for this type of tramway. Also, considerable operating labor would have been required—probably at least three men at the loading terminal and two at the discharge. In this type of tramway the discharge terminal can often be made automatic; but under such conditions the speed of the tramway must be limited, which would mean more carriers, and which again would increase the tension in the traction rope, and all of the aforementioned detrimental conditions would be aggravated.

By examining the profile the decision was reached that, by introducing a transfer station at the hump, two single-span two-bucket tramways could be installed satisfactorily. This would allow the high speed that is desirable in this type of tramway, and would add only one man to the labor force, because a gravity two-bucket tramway can be handled easily by one man at the receiving end. The profile drawing shown herewith indicates how this was accomplished. The plan required a transfer of the material at the intermediate station, but considering (1) the saving in the original cost of equipment, (2) a much greater saving in the cost of installation, and particularly the economy of labor, this was seen to be the best arrangement.

The installation has been operating for nearly two years, considerably exceeding its rated capacity of 150 tons per hour, and so far at practically no cost for upkeep. Labor expense has involved the wages of but two men.

The carrying cables are of $2\frac{1}{4}$-in. diameter, of locked-coil construction; the head ropes of $\frac{7}{8}$-in. diameter of Hercules (Red-Strand) grade; the tail ropes of $\frac{3}{4}$-in. diameter special steel; and the carriers are of 80-cu.ft. capacity, equipped with four-wheel trucks. To have as large carriers on the upper and shorter section as on the lower one would not be necessary, but in this operation all of the equipment was duplicated, including both the carriers and the control equipment. In other words, there are two identical tramways except as to length.

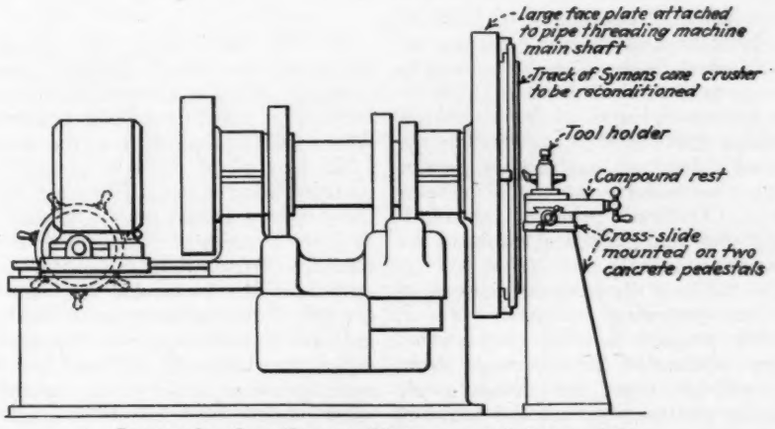
All of the tramway equipment was designed and manufactured by A. Leschen & Sons Rope Company, of St. Louis, Mo. The structures are of reinforced concrete, and in their design the Leschen company collaborated with F. L. Smidth & Company, of New York. The latter company also designed the complete crushing plant located at the quarry, the material handled over the tramway being crushed to pass through a $\frac{5}{8}$-in. screen. Work was carried on under the general supervision of A. F. Krabbe, general manager of the Olympic Portland Cement Company.

■

Repairing Crusher Tracks With Pipe-Threading Machine

WORN Symons cone-crusher tracks, when not replaced or reconditioned in time, will cause increased vibration, noise, and consequent loss of crushing capacity. When no spares are available, the tracks can easily be reconditioned in a large lathe equipped with a face plate of the proper size.

John Langdon, master mechanic at the United Verde Extension's smelter at Clemenceau, Ariz., was recently confronted with such a problem, but unfortunately no lathe large enough for this work was at hand. The problem was solved by converting the large pipe-threading machine into a lathe, as shown in the accompanying sketch. A large face plate was attached to the main shaft of the pipe-threading machine, and two concrete pedestals were placed near the face plate to accommodate the cross slide and compound rest, with tool holder. Automatic feeding of the feed screw was accomplished with a simple device operated by the revolving machine. With the exception of the tool holder, which can easily be removed when desired, the described changes do not interfere in any respect with pipe-threading operations.


Large face plate attached to pipe threading machine main shaft
Track of Symons cone crusher to be reconditioned
Tool holder
Compound rest
Cross-slide mounted on two concrete pedestals

Large pipe-threading machine converted into a lathe

Mining and Milling in the Vermont Copper District

C. S. Anderson
South Stafford, Vt.

MINING of the cupriferous pyrrhotite deposits of Vermont, which deposits closely resemble those of the Ducktown district of Tennessee, dates back a century, the Ely or Copperfield property having been, at one time, the largest copper producer of the country. Other once important mines in the district include the Pike Hill and the Elizabeth-Foster-Cleveland.

The latest effort to revive copper mining in Vermont was made by the National Copper Corporation at the Elizabeth - Foster - Cleveland property. Owing to the recent low price of copper, however, operations had to be suspended, after an initial daily ore production of 150 tons had been increased to 350 tons and plans had been made for an ultimate output of 500 tons. Efficient mining and milling methods were developed, and, with a more favorable price of copper prevailing, the mine will probably be reopened.

The deposits lie in the eastern foothills of the Green Mountains, the country rock being an intensely foliated micaceous schist carrying much calcite. Measured along outcrops of the three important deposits, the copper belt is about 20 miles long. Pike Hill is about 11 miles north of Ely, which is 6 miles north of the Elizabeth-Foster-Cleveland mine. The dip of the orebodies conforms to and varies with the dip of the wall rock schists. At Pike Hill and Ely, the dip is 24 to 30 deg. E.; the Elizabeth-Foster-Cleveland orebody dips 50 to 85 deg. E. The vertical extent of mineralization has not been determined, ore continuing throughout the length of a 3,400-ft. incline shaft at the Ely mine, which has a vertical depth of 1,500 ft. Development and diamond drilling at the Elizabeth-Foster-Cleveland property extends to a vertical depth of 1,055 ft. The horizontal length of the orebody is traceable for 13,000 ft. Although the Ely mine has been explored to greater depth, the orebody at the Elizabeth-Foster - Cleveland property is much larger than that defined at either of the other two mines.

Pyrrhotite is the principal mineral in the ore, occurring intimately and in varying proportions with chalcopyrite. Copper content of the ore ranges from 0.5 to 20 per cent; the average grade mined in earlier operations was probably about 3 per cent. Modern methods of concentration, however, made the handling of ore averaging less than 2 per cent copper economically possible. Large reserves of this grade of ore exist in the Elizabeth-Foster-Cleveland mine, and, inasmuch as the ore contains much sulphur and iron, the manufacture of sulphuric acid and the recovery of iron are possible in connection with treatment of the ore.

The Elizabeth-Foster-Cleveland mine is about 12 miles from the nearest railroad shipping point, Pompanoosuc, on the Boston & Maine Railroad. It was opened in 1793 and worked for its pyrrhotite, which was utilized in the manufacture of ferrous sulphate. From 1830 the copper content became of increasing importance, and the ore was treated by blast-furnace or reverberatory- furnace smelting. Diamond drilling was also done to reveal the extent of the orebody. A magnetic separation plant built in 1905 was a failure. In 1917 this plant was remodeled into a 100-ton flotation plant by the General Engineering Company. A 6-ft. x 22-in. Hardinge mill, a Dorr classifier, and Callow cells were installed. A second flotation unit was added to raise the capacity to 200 tons. Considering the status of selective flotation at that time, results were very satisfactory. Operations continued until April, 1919, the decline in the price of copper following the War causing the property to shut down.

In 1925 the property was leased to the American Metal Company, which company added a sixteen-cell Minerals Separation machine to the equipment. About 20,000 tons of ore was mined, 1,756 tons of 18 per cent copper concentrate being shipped following operations over a period of six months. A drop in the price of copper made a continuance of operations unprofitable, and American Metal canceled the lease. In the fall of 1928 a twenty-year lease was granted National Copper Corporation. After remodeling the mill and installing new grinding machinery, operations were started in April, 1929, and continued until June, 1930, when the low copper price again caused a shutdown. The run, in which 60,000 tons of ore was treated, may be considered as a test to determine a basis for permanent operations. Data for estimating the possibilities of sulphuric acid manufacture from the pyrrhotite were also obtained.

The Elizabeth-Foster-Cleveland orebodies have been formed by replacement along a fault striking N. 18 deg. E. and dipping steeply to the east. No cross faulting of importance is noted. The mineralized zone ranges in width from a few feet to 70 ft., the ore varying from massive pyrrhotite, with little copper, to massive chalcopyrite, 3 ft. wide, containing 20 per cent copper.

In the past much emphasis was placed on the lens shape of the oreshoots. As in most deposits, the ore is not evenly distributed, and the necessity of mining only the higher-grade material tended to limit oreshoots to lens-shaped bodies. When the more cupriferous ore gradated into leaner pyrrhotite, mining was stopped. Recent development, however, has shown that good ore is often found by driving a few feet toward either hanging wall or footwall. Large bodies of ore were found near the walls, where mining had been stopped because the walls were thought to have been reached. The ore appears to exist in a continuous shoot, pitching gently to the north. It is a mixture of pyrrhotite and chalcopyrite, with a small amount of zinc and 0.2 oz. of silver per ton. Gangue minerals are: Quartz, mica, feldspar, calcite, garnet, and tourmaline. The mineralogical composition is about as follows: Quartz, 15 per cent; feldspar, 15 per cent; mica, 10 per cent; pyrrhotite, 53 per cent; and chalcopyrite, 7 per cent. Average assay value for 7,000 tons of ore mined during March, 1930, was as follows: Copper, 2.29 per cent; zinc, 0.32 per cent; iron, 36.40 per cent; and sulphur, 23.02 per cent. The copper content of 60,000 tons of ore mined during 1929-1930 was 2.11 per cent.

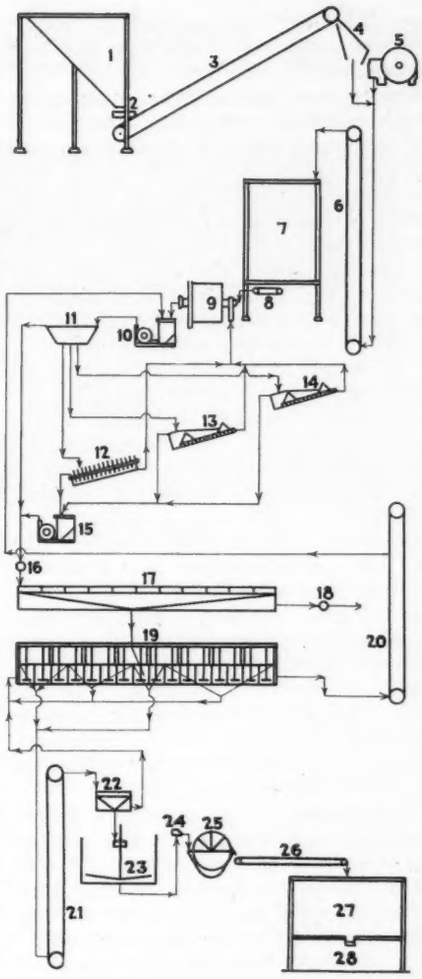
Early mining operations at the property were confined to an open-cut with a short adit. Underground mining started in 1886, following the sinking of a 160-ft. vertical shaft. At present the mine is entered through the Tyson adit, 7x9 ft. in cross-section, driven on an average grade of 2.25 deg. A 26-in.-gage Jeffrey trolley locomotive hauls two 5-ton Granby cars from the loading

chutes to the mill bin. From the end of the adit, drifts have been run 620 ft. southward and 230 ft. to the north along the strike. This level is known as the 225-ft. or "D" level. The south end extends under and is connected with the earlier underground workings. Much ground formerly considered too low in grade is still available, together with some high-grade ore recently disclosed that was evidently overlooked by former operators.

A 30-deg. incline shaft, 25 ft. to the north of the adit, has been sunk 810 ft. to a point 330 ft. vertically below the "D" or haulage level. From this shaft levels have been opened up at 90 ft. ("E" level), 220 ft. ("G" level), and 310 ft. ("H" level), vertically below the collar. Level "E" has been driven 400 ft. south and 140 ft. north and connected with the haulage level. Level "G" has been driven 190 ft. south and 290 ft. north. To the north of the shaft on this level some stoping has been done, and raises have been put up to a sublevel between "E" and "G" levels. Inasmuch as "E" level does not extend over "G" level to the north, no raises connect these two levels. The bottom level, "H," extends 900 ft. north of the shaft. The face of the level heading is in high-grade ore, narrow in width. A horizontal diamond-drill hole has been driven 250 ft. north from this face. When operations ceased in June, 1930, a raise was being driven to connect level "H" with the level above. The horizontal distance from the south end of the haulage level to the north end of the lowest level is 1,800 ft.

About 13,000 ft. of diamond drilling has been done from the surface to trace the orebodies along the strike. Drill logs are available for estimating positive drilled ore, a term used to designate ore cut by the drill outside the limits of that developed underground. Calculated ore reserves are: Positive developed, 233,000 tons, analyzing 2.07 per cent copper, 18.7 per cent sulphur, 31.60 per cent iron; positive drilled (Foster section), 802,000 tons, analyzing 1.35 per cent copper, 15 per cent sulphur, 26 per cent iron; positive drilled (Elizabeth section), 530,000 tons, analyzing 2.25 per cent copper, 13.5 per cent sulphur, 24.35 per cent iron. Total ore reserves: 1,565,000 tons averaging 1.76 per cent copper, 15.1 per cent sulphur, 26.25 per cent iron. Inferentially and geologically, several times this tonnage may reasonably be expected.

When mining began in April, 1929, shrinkage stoping was first tried. This method at first seemed to be satisfactory, but disadvantages soon became apparent. The broken ore oxidized rapidly and was difficult to treat in the mill. A change to underhand stoping became necessary. Raises were put through from one level to the next above. Stoping started at the top of the raise by widening to the walls; the ore was then mined progressively downward by benching. On account of the steep dip, the ore dropped without shoveling to the chute below. Advantages gained by this "mill holing" system were (1) the ore reached the mill soon after being broken, and (2) jack-hammers could be used—an important consideration, as experienced miners were scarce and green men could easily be taught to use that type of drill. Besides, as the ore broke in large pieces, and much block-holing and chute blasting were necessary, another advantage of "mill holing" was that it made chute hang-ups easier to handle.



Flow sheet of the Elizabeth-Foster-Cleveland mill

1. 250-ton coarse-ore bin.
2. Reciprocating feeder,
3. 24-in. conveyor.
4. Grizzly.
5. 13x30 in. Farrell-Bacon jaw crusher.
6. 20-in. belt bucket elevator.
7. 160-ton crushed-ore bin.
8. 24-in. apron feeder.
9. 86-in. Marcy ball mill.
10. 6-in. Wilfley pump.
11. Three-spigot hydraulic classifier.
12. 54-in. Akins classifier.
13 & 14. Two 4-ft. 6-in. duplex Model C Dorr classifiers.
15. 3-in. Wilfley pump.
16. Galigher automatic head sampler.
17. Southwestern flotation machine.
18. Galigher automatic tail sampler.
19. 18-in., 16-cell, Sub-A. M.S. machine.
20. Bucket elevator.
21. Bucket elevator.
22. 6-ft. Forrester flotation machine.
23. 16x8-ft. thickener.
24. 4-in. Gould diaphragm pump.
25. 8x8-ft. Oliver filter.
26. 12-in. belt conveyor.
27. Concentrate storage bin.
28. Concentrate bin discharge gate.

The walls stood well, and no timber was required. Chutes were made from 12x12 in. timber, with sides and bottom of 5-in. material. Ore from the lower levels was hoisted in a 2½-ton skip by means of a single-drum Ottumwa friction hoist, driven by a 35-hp. d.c. motor. The skip dumped into an old stope above the haulage level, serving as an ore pocket, and the ore was loaded into 5-ton cars. On the lover levels ore was hand trammed to the skip pockets.

Initial production, at the rate of 150 tons of ore per day, was gradually increased to 350 tons. When the mine was closed down, preparations for a daily output of 500 tons were under way. Experienced miners were scarce, and the few available had to be used at first to instruct the other men. The various types of rock drills employed were: IR No. 174 and CP No. 6 drifters; Denver No. 11 sinkers; and IR Jackhamers and stopers. All drill steel was sharpened underground with a coke-fired forge, an IR No. 5 sharpener, and a No. 8 pedestal grinder. A two-stage, 22x14x16-in. Sullivan compressor situated in the mill building and driven by a 150-hp. motor furnished air for drills and pumps. Direct current for the electric haulage, hoist motor, and lighting was delivered at 250 volts by a 60-kw. motor-generator set. Pumping was done a few hours a day with a 7-in. Cameron sinking pump.

Remodeling of the mill, begun in January, was finally completed in April, 1929. The construction crew was transferred to the mill and trained for that work. Power shortage and mechanical defects of the old equipment made even a 24-hour run impossible. Careful attention to metallurgy or to proper training of flotation operators could not be given for a long time. Not until July was adequate power available. Later, a series of violent electrical storms burned out transformers and motors. The Marcy ball mill and the M.S. flotation machine were new and gave no mechanical trouble. While the mine was being prepared for stoping, most of the ore came from a supply left in old stopes. This ore was found less amenable to flotation than the freshly broken ore that had been used for testing purposes.

Concentrate of good grade was made, but recoveries were erratic and poor. Gradually, mechanical troubles were ironed out and a satisfactory milling practice developed. Many flotation reagents were tried before the right combination was determined by experiments made on the ore at the Colorado School of Mines. Not until

shrinkage stoping was discontinued, however, were satisfactory results of regular occurrence. With freshly broken ore such results were dependent on proper grinding and sufficient time of contact in the flotation section.

The initial mine production output of 150 tons was gradually increased, and additional classifiers, flotation machines, and pumps were installed. For economic reasons old machines on hand were utilized and some makeshifts were inevitable. By April, 1930, the capacity of the flotation machines was reached, 250 to 275 tons per day being milled. A pneumatic flotation machine of 400 tons' capacity was installed, and early in May production was stepped up to 325 tons. During this final month of operation the mill handled as much as 370 tons in 24 hours. A recovery of 90 per cent was made, the concentrate containing 20.36 per cent copper. The mill functioned properly, and the crew had become efficient. A brief description of the milling practice follows.

The ore, broken by hand or blockholed to pass an 8-in. grizzly, dropped into a 250-ton bin, whence it was delivered by a reciprocating feeder to a 24-in. belt conveyor, with a 20-deg. slope, that discharged onto a 2-in. grizzly. Oversize went to a 13x30-in. Farrell-Bacon jaw crusher, with a 2-in. discharge. Undersize and the crusher product were delivered by a bucket elevator to a 160-ton bin. The crushed ore, nominally minus 2 in. but containing much slabby material of larger dimensions, was fed with a 24-in. Stephens-Adamson apron feeder to a No. 86, 22-r.p.m. Marcy ball mill, driven by a 250-hp. slip-ring motor through a speed reducer. A 22,000-lb. ball load of 5-in. forged chrome-steel balls was used, comsumption averaging 1.6 lb. per ton of ore. Liner consumption was about 0.4 lb.

Solids in the ball-mill discharge varied from 50 to 87 per cent. The lower percentages resulted in an excessive circulating load; the higher had disastrous effects on flotation. A satisfactory ratio was found to be 20 to 75 per cent solids. Poor metallurgical results that were obtained may be explained by sliming of chalcopyrite and perhaps, also, by improper diffusion of the reagents. The ball-mill discharge was lifted 35 ft. with a 6-in. belt-driven Wilfley pump to a three-spigot hydraulic classifier that overflowed into a flotation rougher. About half of the spigot discharge was sent to a 54-in. Akins classifier, and half was divided evenly between two Dorr duplex Model C classifiers. Oversize from the mechanical classifiers was returned to the feed box of the ball mill, thus closing the grinding circuit. The circulating load averaged 300 to 350 per cent of the initial feed, with recorded variations up to 600 per cent.

A slope of 2¾ in. to the foot gave the best results with both types of classifiers. Speed of the Akins spiral was 6½ r.p.m., and the Dorr rake operated at twenty strokes per minute. The pulp overflow contained 35 per cent solids. This density was selected after experiments with overflows containing from 25 to 45 per cent solids. The maximum size of feed for good flotation results was determined to be 65 mesh. Normally, 50 to 60 per cent of the flotation heads would pass a 200-mesh screen.

Overflow from the classifiers, sampled every fifteen minutes with a Galigher automatic sampler, was pumped with a 3-in. Wilfley unit to a flotation machine built locally from drawings furnished by Southwestern Engineering. The machine was originally a "Welsh" type unit, but modifications that were necessary for efficient operation made it resemble a "Forrester" machine. A rougher concentrate and a final tailing were produced. The tailing, assaying 0.10 to 0.20 per cent copper, was sent to a tailing dam after being sampled with a Galigher sampler. Rougher concentrate, containing 8 to 10 per cent copper, passed to a sixteen-cell, 18-in. Sub A. Minerals Separation machine for cleaning. Before the air machine was put in operation, the M.S. machine, with a 6-ft. Forrester cell for recleaning, handled 275 tons daily.

Using the M.S. machine as a cleaner resulted in a high power consumption for that purpose. In milling 350 tons daily, power consumption for the flotation machines was 5.6 kw.-hr. per ton, 2.5 of which was for roughing and 3.1 for cleaning. Two No. 3 and one No. 2 Root blowers furnished the required air. Rougher concentrate was added to cell No. 7 of the M.S. machine, and concentrate from cells Nos. 7, 8, 1 and 2 was sent to the 6-ft. Forrester for recleaning, if necessary. The final concentrate assayed 18 to 22 per cent copper. Cleaner tailing, assaying 0.5 to 0.6 per cent copper, was returned to the circuit at the discharge box of the ball mill.

The final concentrate was elevated to a 16-ft. thickener, the underflow containing 40 to 50 per cent solids being delivered by a 4-in. diaphragm pump to an 8x8-ft. Oliver filter. A small centrifugal pumped the clear overflow to a tank above the ball mill, the water being used as required for make-up water in the classifiers. The Oliver filter, operating under a 20-in. vacuum, made a cake containing about 11 per cent moisture. A 12-in. belt conveyed the filter product to a storage bin, whence it was loaded into trucks and hauled to the railroad for shipment to Chrome, N. J.

Reagent consumption per ton of ore milled was as follows: Lime, 2.3 to 2.6 lb.; pine oil, 0.04 to 0.10 lb.; potassium amyl xanthate, 0.10 to 0.17 lb.; thiocarbanilide, 0.08 to 0.15 lb.; orthotoluidine, 0.03 to 0.10 lb. Alkalinity of the pulp was controlled by *pH* measurements, and about 85 per cent of the lime was fed to the ball mill to maintain a *pH* of 9.3 to 9.6 in the tailing water. The rest of the lime was added in the cleaner circuit, where the *pH* was maintained at 10.1 to 10.4. Portland cement, used as a substitute for lime and in equal amounts, produced about the same alkalinity as lime, recoveries also being comparable.

A screen analysis of a weekly composite sample, showing the distribution of copper and the recoveries at the different screen sizes, is presented in the accompanying table. The comparatively large proportion remaining on 65 mesh is explained by the fact that it is mostly mica. Average assay values of composit samples were: Heads, 1.93 per cent copper; tailing, 0.158 per cent copper. These values indicate an extraction of 91.8 per cent. Ratio of concentration for the entire period of operation was 12 to 1.

Values presented in the table indicate that copper content and recoveries were fairly well distributed in all the sizes finer than 65 mesh. Grinding all the pulp to pass 100 mesh was considered, as well as regrinding the rougher concentrates before cleaning. Both ideas were rejected, however, inasmuch as resultant operations would probably have been less profitable than those that were employed.

Water for milling, cooling, and domestic purposes was pumped against a 500-ft. head to a 20,000-gal. storage tank with an Allis-Chalmers centrifugal pump driven by a 60-hp. motor and rated at 200 g.p.m. Water consumption averaged three tons per ton of ore milled.

Continuous operation of the property will necessitate recovery of the sulphur and iron in the ore. Tests made during the final period of operations at the property showed that an iron concentrate suitable for the manufacture of sulphuric acid and for the production of iron sinter could be made. The property offers a ten-year supply of high-sulphur ore. Reopening of other mines in the district would add to the supply of ore from which an acid plant could draw.

In conclusion, I wish to express my thanks to the management of the National Copper Corporation for permission to publish the foregoing account relative to the company's operations.

Screen Analyses and Assay Values

Mesh	Heads, Per Cent by Weight	Assay Value, Per Cent Copper	Tailings, Per Cent by Weight	Assay Value, Per Cent Copper	Recovery Per Cent
Plus 65 mesh	10.5	0.78	11.4	0.158	79.6
Plus 100 mesh	7.6	1.26	8.9	.187	85.2
Plus 150 mesh	11.1	1.94	14.5	.187	91.1
Plus 200 mesh	11.7	2.17	12.4	.126	94.2
Minus 200 mesh	59.7	1.97	53.3	.175	91.2

Pre-Cambrian Conceptions

A prospector's camp in the Canadian "bush"

Arnold and Robert D. Hoffman

Mining Geologists,
New York, N. Y., U. S. A.

MINERAL POSSIBILITIES of the Pre-Cambrian areas in Canada have received much attention from various writers in the last few years, particularly since C. V. Corless delivered his presidential address to the Canadian Institute of Mining and Metallurgy in 1922, when he alluded to "the inexhaustible wealth of the Pre-Cambrian." C. M. Campbell took up the cudgels against Mr. Corless in the Institute publication. In the Aug. 4, 1928, issue of *E.&M.J.* he wrote a paper, "Pre-Cambrian Misconceptions," which gave rise to considerable controversy, printed and otherwise. We have been connected intimately with Canadian mining development since 1921, and in this paper will endeavor to emphasize conclusions gained through personal experience or little known historical fact.

The fact that the first two Pre-Cambrian mining camps in Canada were discovered accidentally is ancient history. Both Sudbury and Cobalt were born through the exposure of mineral in railroad cuts—Sudbury in 1883, Cobalt in 1903. Extensive prospecting for twenty years after the Sudbury discovery failed to disclose a new camp. Finally, in 1903, McKinley, Darraugh, and La Rose stumbled upon silver in Cobalt. A flood of prospecting which immediately followed this event resulted in the discovery of Gowganda in 1908; Porcupine, 1909; Kirkland Lake, 1911; Flin Flon, 1915; Rouyn, 1923; and Sherritt Gordon, 1924. The gold discovery at Swastika, Ont., 1906, did not prove to be economic, but it furnished the impetus for Kirkland Lake, 4 miles distant. Rouyn's discovery is given as 1923 rather than 1920, for it was not until August, 1923, that the Thomson-Chadbourne syndicate demonstrated the possibilities of an economic property on the Horne group of claims. In short, from 1903 to 1923, three major camps were found in Ontario (Cobalt, Porcupine, Kirkland Lake), and one minor camp (Gowganda); one major camp in Quebec (Rouyn), and one minor camp (the Hurricanaw area with one producing mine, Siscoe); two camps in Manitoba (Flin Flon and Mandy, and Sherritt Gordon.)

IN 1925, an intensive search for new mines was instituted throughout Canada with leading Canadian mining companies in the field as well as organizations newly formed for exploration purposes. Northern Aërial Minerals Exploration and Dominion Explorers made determined efforts to "crack open" the North through the systematic use of hydroplanes. Since 1925, according to trustworthy estimate, approximately $10,000,000 has been spent in fruitless prospecting of the Pre-Cambrian.

From the foregoing one might infer that Canada has been adequately prospected and its mineral possibilities exhausted. We hold that the reverse is true, when the number and character of prospectors are considered. The Westerners who appeared magically in Cobalt at the time of the find soon quit, because of the small dimensions of the veins and the difficulties of traveling the "bush." Those who stayed after the boom of 1906 were largely farmers, woodsmen, and city dwellers who had decided upon a new mode of livelihood. By 1914 these men had developed a keen sense of prospecting technique and were fast becoming acquainted with the puzzling character of Pre-Cambrian mineralization. Then came the War, and with few exceptions the prospectors thronged into the army. A mere handful returned from France. The period immediately following the cessation of hostilities found a very small number of men in the bush. The so-called Rouyn area, 100 square miles, was solidly staked in 1922-23 by no more than 25 prospectors. The Red Lake rush of 1925-26 was the work of substantially the same group of men. And the Manitoba discoveries and stakings were also carried out by this little band of Ontario prospectors, most of whom came from New Liskeard and Haileybury. In fact, all the mineral discoveries since 1920 can be traced to the men of these two small towns. The question suggests itself: could a score of men, stakers rather than prospectors, thoroughly comb a continental area in a few years? We think not.

MINING men readily admit that northern and northwestern Canada is among the most difficult prospecting areas of the world. Deeply overburdened, heavily forested, covered largely by swamp muskeg and water, it offers comparatively few rock outcrops. There are no gossans, as in Arizona, to guide the prospector from afar to the mineralized outcrop. Except for recently burnt areas, visibility rarely exceeds 100 ft. The glaciers have planed off all pre-existing gossans, and whatever remnants still exist are covered with overburden or growths of fungi. Accidental uncovering of moss, an overturned tree, sinking of water level in river or lake, a bush fire, may constitute the difference between a new mining camp and virgin forest. Once scarred by fire, the bush does not remain bare; new vegetation springs up so quickly that in a few years the outcrops are once more covered and visibility is again limited. The prospector knows whereof he speaks when he says, "It's a son of a gun, Canada."

As regards aërial prospecting, imagine a stretch of country roughly approximating the area included between the four focal points of New York City; Butte, Mont.; Albuquerque, N. M.; and Charleston, S. C. Twenty planes wing over this hinterland for a sporadic period of three years. What are the possibilities of so detecting the favorable zones for investigation? Not great, surely. In rare cases gossans have been seen from the air at a distance of 5 miles, notably that located at the water's edge of Rottenstone Lake in Saskatchewan. It is our contention, however,

Creek traveling in the summer of 1922 near the site of the Ashley gold deposit, discovered in the Matachewan area in 1930

that aërial prospecting in Canada is generally futile. The airplane is useful for speedy and otherwise impossible transportation of men and supplies, extending the field season, and serving as a time saver, but it offers little service, *per se*, in prospecting.

FROM 1925 to 1929 a period of intensive prospecting took place. Much of the field work was conducted by geological students and fresh graduates of mining schools. Their knowledge was limited to differentiating minerals in the field; their comprehension of ore deposits was for the most part undeveloped. Such work as theirs may be regarded as valuable only in so far as it provided training for the more serious work of exploration in the future. A considerable part of the campaign for new mines, also, consisted of electrical prospecting, which did not result in finding a single deposit of importance.

The working out of geological structure in the Pre-Cambrian is not easy. Outcrops are few, and wherever found the rocks are folded, sheared, schisted, and altered—so much so that it is unwise to project an outcrop more than a few feet from the range of the eye. Even in Sudbury, structural relationships are still obscure after 45 years of underground work. Geological work, therefore, must proceed slowly in the newer areas, and the time element must be reckoned in decades.

To strengthen our postulate that Canada has not been thoroughly combed and that prospecting, contrary to popular conception, is yet in its infancy, we shall briefly review the known mining camps in the Pre-Cambrian with special emphasis upon the original surface discoveries. Nearly all these discoveries were accidental. Most were made in areas which had been inhabited or frequently traversed for many years previous to discovery.

Sudbury begins the mineral history of the Pre-Cambrian. Situated close to Georgian Bay, it was for more than a hundred years previous to the discovery known as a fur and timber country. Yet, not until the Canadian Pacific Railroad construction work exposed heavy mineralization in the cut where the Murray mine is now situated, did the area assume mining possibilities. The cut showed a mineralized width of 50 ft. Cyril Knight, writing for the Ontario Nickel Commission in the 1917 report, pp. 28-58, gives a detailed historical sketch of the Sudbury discoveries, and to this the interested reader is referred.

COBALT is only 5 miles from Lake Temiskaming, used as a main canoe route for fur traders since the dawn of the eighteenth century. About 1740 a party of French voyageurs discovered a deposit of galena (Wright mine) along the southern shore of the lake, only 12 miles from the present Keeley silver mine, South Lorrain, and 25 miles from Cobalt. A fur-trading post was maintained on the site of Haileybury, only 5 miles distant. Timber operations were carried on close to Cobalt in the late years of the nineteenth century, and shortly thereafter a farming community sprang up at New Liskeard, 10 miles from Cobalt. Yet we owe the discovery of Cobalt to the Temiskaming & Northern Ontario Railroad, which was projecting its line northward in 1903. Had the right-of-way been surveyed one mile to either side, the discovery might have been deferred for many years or might conceivably never have been made. The small veins, often only an inch wide, rarely more than 200 ft. long, yielded chunks of solid silver at the outset.

The Porcupine area was surveyed about 1903-04, and homesteads were allotted to veterans of the Boer War. W. A. Parks, in his report to the Ontario Bureau of Mines, Vol. X, 1900, noted a series of quartz veins carrying low gold values. At that time there was a portage route—from Nighthawk Lake to the Mattagami River, via Porcupine Lake, Pearl Lake, Gillies Lake, and Miller Lake—crossing the present McIntyre and Hollinger mines.

IN June, 1909, a party of prospectors, including J. Preston, of Matthewson, Ont., was working close to Porcupine Lake, where Bannerman had made a gold discovery earlier in the year. Preston, while tramping through a swamp, climbed to the top of a moss-covered rock to escape the black flies. In picking off a handful of moss he exposed what was later called the famous "Golden Sidewalk" of the Dome Mines. Trenching and stripping followed feverishly and showed gold to be distributed over an area 150x40 ft. In the meantime, Cleary Dixon and Tom Middleton had staked claims to the west of Pearl Lake. On their way out, Dixon met Preston, who spoke of a considerable area of "white rock" near a small lake southwest of the "long lake" (Gillies Lake). When Dixon and Middleton returned to Haileybury and spoke of their findings, Jack Miller, Dixon's

The "bush" after a forest fire

stepfather, sent Alex Gillies to Porcupine to stake more ground. With Gillies was Benny Hollinger. Each man, however, staked separately for his respective principals. Dixon and Middleton did not stay in Haileybury but followed close on Hollinger's heels to stake the Miller-Middleton group southwest of Hollinger's famous locations. They found free gold in narrow blue quartz veins as they planted their posts; in fact, they experienced some difficulty finding spots without the incriminating presence of the yellow splotches. Dixon, before his death in 1926, told us that, in performing assessment work on the Acme ground, he discovered several quartz veins rich in gold immediately in the path of a well-traveled portage. Many particles of gold were scratched in places

The North's innumerable lakes make the canoe the most reliable means of transportation. These prospectors are breaking through a beaver dam

where the hobnailed boots of unknowing prospectors had scraped them. There was a large quartz boulder near the top of a hill where a man had stood to blaze a spruce tree. Underneath, according to Dixon, was a piece of native gold ¼ in. in diameter showing the telltale mark of the blazer's boots! Sandy McIntyre stated in a personal communication that he found a very rich occurrence of gold on the site of the old McIntyre mill, on the south side of Pearl Lake. This did not make the McIntyre mine, however. The real veins constituting the mine were developed under Pearl Lake.

THUS, though the Porcupine area was traversed by an old canoe route and cut into 160-acre lots by the Ontario land surveyors, and the occurrence of gold-bearing quartz veins noted and published in a government report, the field was not discovered until a later time, and then the discovery was by pure accident. The original discoveries on the Hollinger and Dome mines were so rich that their prime importance was immediately recognized. In passing, the fact may be mentioned that the 100 level of the Dome was of very low grade. Had erosion been carried downward another 100 ft., Porcupine may have remained undiscovered for years.

Kirkland Lake was discovered in 1912, six years after the "find" in Swastika. In this camp, the first discovery was on the Tough-Oakes property, where a narrow vein, 6 to 24 in. wide, 250 ft. long, was uncovered in a reddish syenite. The surface assays were very high, $25 to $100 in gold per ton. Between 1913 and 1918, nearly $2,000,000 was taken from the property. The Wright-Hargreaves had a quartz vein 5 ft. wide, 400 ft. long, in the conglomerate which averaged $10 in gold per ton. Lake Shore, at that time, had no commercial deposit on the surface. The No. 2 vein, which "made" the mine, was found several years later in a crosscut under Kirkland Lake, driven to cut the westward continuation of the Wright-Hargreaves vein. Teck-Hughes had no extensive commercial oreshoot on the surface, and none was encountered until work had been carried down below the 500 level. In short, there was originally one high-grade oreshoot on the surface in the Kirkland Lake camp in 1914, with another interesting shoot of modest dimensions to the west. Rash indeed would have been the person who, on the basis of surface indications, dared to predict a production in gold of more than $15,000,000 for 1929.

In Rouyn, the earliest discoveries were those of Horne in 1920, Wright in 1922, and Powell in 1922, all of which gave little promise of economic deposits. All early work was based on the gold mineralization, no one even suspecting the existence of the copper deposits. The engineer who examined the Horne group for the Thompson-Chadbourne Syndicate reported negatively. Original showings at the creek, pyritized rhyolite, carried only low gold values below the gossan. The showing that actually overlaid the mine deposit was a massive pyrrhotite carrying about $5 per ton in gold, with no copper reported. Had not the courageous syndicate persisted in its development work on the Powell, the Chadbourne, and finally the Horne groups, we doubt whether Rouyn would ever have become the camp it now is. The success of the Horne development in 1923 led to renewed work in 1924 and 1925, and resulted in discovery of the Amulet and Waite-Montgomery deposits. Amulet was found by a member of Huronian Belt staff after the Duprat-Dufresnoy area had been burnt. He cut a trail over what is now Amulet ground to the Huronian options to the west. A work trail passed over the south showing, which consisted of a few small patches of mineral. Rouyn was one camp where no ore was disclosed in the original surface showings.

NO ORE outcropped on the surface of the Flin Flon mine (Hudson Bay Mining & Smelting), in Manitoba. The original find was made beneath the lake when an Indian, in setting his traps, noticed the color of the rock beneath the water surface. He informed a party of prospectors headed by Creighton and Djon, who announced their discovery in 1915. Subsequent development of this deposit is well-known history. Similarly, the Sherritt Gordon mine was found by Sherlett, an Indian, but the surface showing was too small to develop.

Can the future be guided by the experience of the past? We think so. There is no reason to suppose that the character, size, and importance of deposits to be found will differ radically from those already developed and being developed. The fact that most of the Pre-Cambrian mines have been found accidentally and that their original outcrops have generally been small induces the thought that more will be discovered by properly conducted searching.

MINES of the Canadian Pre-Cambrian are confined largely to two great areas of Keewatin[1] and Huronian[2], one in Saskatchewan and Manitoba, embracing the Flin Flon, Mandy, and Sherritt Gordon mines, and the other Ontario and Quebec, embracing the Sudbury, Cobalt, Kirkland Lake, Porcupine, and Rouyn fields. The association of mineralized areas with Keewatin and Huronian rocks was recognized at an early date by Canadian geologists, and mapping was undertaken to define such areas. Compared to the huge Pre-Cambrian region, about 2,000,000 square miles in Canada, the exposures of Huronian and Keewatin are 200,000 square miles in extent, or 10 per cent. This ostensibly cuts down favorable prospecting country in the Pre-Cambrian, yet the actual extent of Keewatin and Huronian is great enough to warrant field investigations for several generations. In a letter to *E.&M.J.* on Dec. 29, 1928, we pointed out the extent of favorable virgin Huronian areas in addition to the well-known Manitoba, Quebec, and Ontario areas noted in the foregoing. We shall repeat the list with slight additions:

[1]Keewatin as here used is a generalized term which included all old flows and undifferentiated sediments included in these flows grouped as the oldest Pre-Cambrian.
[2]Huronian is here used to include the Upper Pre-Cambrian, Temiskaming, and Huronian sediments and Keweenawan intrusives.

1. The area of Keweenawan rocks along the Kaniapiskan River in the interior of Labrador. A part of this section has been aërially prospected since 1928 with no discoveries reported.

2. The area of Keewatin rocks, comprising 5,000 square miles, north of the transcontinental railroad in Quebec. Here, in the fall of 1929, a gold-copper find was made at Opemiska Lake. The small amount of development already indicates that this discovery is of economic importance.

3. The area of Keweenawan rocks in Saskatchewan south and southwest of Lake Athabasca, 20,000 square miles. Scattered zones of mineralization have been reported, but no major finds.

4. The area of Keweenawan at Chesterfield Inlet, 15,000 square miles. No discovery of major importance. Prospecting began in 1928.

5. The Keewatin area in the Rankin Inlet section, 4,000 square miles. The Knight Prospecting Company discovered a sulphide deposit here which was diamond drilled during 1930.

6. The Coppermine area of Keweenawan comprising 100,000 square miles. Work in this region was carried out during the last two years by Dominion Explorers and N.A.M.E. So far it has indicated that mineralization consists chiefly of sulphides and not native copper as had been supposed. Several discoveries of small high-grade copper deposits have been made, but none are of sufficient extent to warrant development at this time. Eventually this area may be an important source of copper.

7. The area of Kissenew schists in Saskatchewan, about 15,000 square miles in the western extension of the Sherritt Gordon area. Various mineralized zones have been reported to date, but no economic deposit has been developed.

8. Oxford Lake, God's Lake, Knees Lake, Favorable Lake, and Sandy Lake Keewatin areas constituting several thousand square miles. The discovery at Oxford Lake in 1928 was found not to be of economic importance.

WE PRESENT this list to demonstrate the advisability of confining prospecting to the large Huronian and Keewatin areas. There is, on the other hand, some possibility that small stocks of Algoma granite intruding the huge areas of Laurentian gneisses and granites may have carried commercial gold mineralization, but in our minds the Laurentian is poor prospecting ground.

In the last ten years the various gold deposits of Ontario have become better known and certain genetic relationships have been established. Cyril Knight, in his Lightning River Report, 1922, pointed out the association of the gold occurrences with the Temiskaming sediments and suggested two main gold belts—the Porcupine belt extending through Lightning River and Quebec, and the Kirkland Lake belt, extending through Larder Lake. H. C. Cooke in 1920, *Journal of Geology*, made a rough correlation of the Quebec belt of sediments from Dasserat Township eastward to the Hurricanaw, offering this area as an extension of the Kirkland Lake-Larder Lake band of Temiskaming sediments, and suggested Quebec as a favorable prospecting section. With the revamping of the Quebec mining laws in 1922, Cooke's suggestion was followed, with the resulting rapid development of the Rouyn area. From our work in the field we have come to believe that the bands of Temiskaming sediments represent major lines of weakness favoring intrusives. At the same time it is our opinion that exploration work should not be confined to these areas alone, but should embrace, also, the areas immediately north and south of the sediments. It is well to keep in mind that the Hollinger and McIntyre mines, in Porcupine, are not in the sediments.

B. S. Butler in 1916 offered a paper in which he made an outstanding contribution to ore genesis. His work on the ore deposits of Utah showed him that there was a close relationship between the ore and the intrusive stocks. He noted, also, how small apically truncated stocks were especially favorable for the location of ore deposits along their flanks, where fracturing had occurred. This idea has been further developed in Canada, where the work of Burroughs, Hopkins, Knight, Wright, Robinson, Cooke, and others has shown the relationship between the gold deposits and acid stock-like intrusions of porphyritic nature. Most prospectors and engineers now search out these areas of small intrusive stocks.

The 1925 Canadian "boom" is well known. Countless small companies were quickly formed to acquire any kind of mining property, syndicates flourished, prospectors became "mining men"; mining brokers became magnates over night. The fatal collapse is perhaps even better known, and it is not our purpose to dwell upon the effective period of deflation which has spread havoc throughout the Dominion. What, however, can be learned from this unhappy interlude?

The first lesson should be the recognition of the impracticability of venturing too far afield by aërial prospecting. Second, huge prospecting companies and syndicates with large capital structures are too cumbersome for the deft work they purpose to carry on. Third, mines are found in the earth and not created merely by formation of exploration companies. Fourth, small units, individual prospectors' parties backed by private syndicates, function best, and, finally, the element of time is of paramount importance. That is, the development of mines is at best a long and often a tortuous process.

From the nature of the North country and our past experience, we are firm in our belief that the Canadian Pre-Cambrian is admirably suitable for individuals with little capital. Provided an area close to the railroad is chosen, the cost of a summer's season in the field should not exceed $400 per man. If, then, development work is found necessary, the various supplies and tools will extend this total by approximately $200. No exclusive concessions are granted to anyone, and the individual enjoys equal privileges with the largest organizations.

The "boom" lulled effective prospecting. Many reported discoveries were often hastily and inadequately investigated. This, plus the dense nature of the bush, makes it advisable to prospect the older regions, especially those where mines are known to exist. *The Northern Miner* has been strenuously advocating adoption of this idea, and we are heartily in accord. The recent Ashley find in Bannockburn Township, Matachewan, demonstrates that reprospecting old areas may bear sudden fruit. We suggest, particularly, the area stretching from West Shining Tree to Porcupine, the area from Rouyn to the Bell River eastward, and the area between the transcontinental railroad and Chibougamau. The day when cutting claim posts was the prospector's chief concern has passed, we hope, and now should come intensive prospecting.

Canadian officials, both Dominion and Provincial, co-operate closely with the prospector, as do, also, the banks, railroads, and mining companies, regardless of his nativity, for Canada opens its borders to all. The Geological Survey maintains an information service at Ottawa, where any printed geological data may be obtained. Similarly, the Ontario and Quebec Bureau of Mines, at Toronto and Quebec City, respectively, welcome inquiries. Recently the Manitoba Bureau of Mines was formed and its office opened in Winnipeg. The Canadian National Railways has in its Toronto office maps and reports of the various mining districts. Whenever a discovery is made in an unmapped region, the Dominion or Provincial bureaus, or both, compile a geological may to facilitate prospecting.

IN CONCLUSION, we would summarize our experience in the Canadian Pre-Cambrian by emphasizing again that it offers, in our opinion, the best opportunity in the world for the prospector or technical man of limited resources. New mines will be found in the future, with courage playing an important part in their success.

Unquestionably, there has been overemphasis of the "unlimited richness" of the Pre-Cambrian area, and that overemphasis has had unhappy consequences. Nevertheless, the intrinsic potentialities of the area should not be minimized or forgotten in a period of deflation and reaction such as the industrial world is now experiencing. To paraphrase the elder J. P. Morgan's advice to his son concerning the future of the United States, we would say, "Don't sell the Pre-Cambrian of Canada short."

The Sullivan Mine

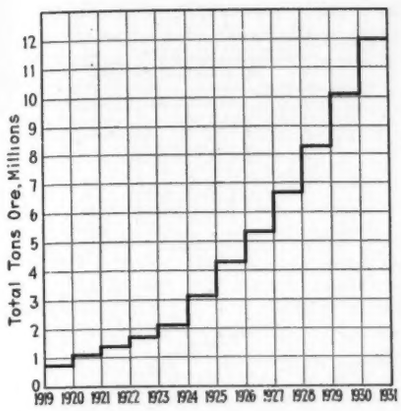


Fig. 1—Progressive increase in Sullivan mine output since 1920

The first of a series of articles on the technical practices and achievements of the Consolidated Mining & Smelting Company of Canada, operating in British Columbia

George J. Young

Associate Editor, San Francisco

IN ITS Sullivan Mine, at Kimberley, B. C., the Consolidated Mining & Smelting Company of Canada has one of the greatest lead-zinc deposits of the world. Its possibilities were not realized at the time of its discovery, in 1892, nor for many years thereafter. In those days complex lead-zinc orebodies offered serious metallurgical difficulties that have now been largely surmounted, thanks to selective flotation. The Sullivan produced from shallow workings until 1908, when it was closed down. The next year Consolidated Mining & Smelting Company's engineers examined the property, and it was purchased in 1910. Its immediate prospects, though, were dubious, and the company had to look long into the future to make the purchase appear attractive.

Five years later electrolytic zinc was being produced from Sullivan ore, and during the last fifteen years metallurgical progress in the treatment of this ore has been so great that the value of the mine has been greatly enhanced. The wisdom and judgment of Selwyn G. Blaylock, now general manager, in recommending its purchase years ago, has been amply confirmed. Before 1920, less than a million tons of ore came from the Sullivan; in the last ten years its output has been between ten and eleven million tons. Fig. 1, showing cumulative tonnages, indicates the increase beginning in 1920. The concentrator has a capacity of 6,000 tons per day, thus indicating the maximum annual production of the mine with present equipment at about 2,000,000 tons. The actual tonnage produced in 1930 was 1,942,137 tons.

Lindgren states that the ore, a high-temperature equivalent of the Coeur d'Alene lead deposits, is a replacement occurring in the Aldridge argillaceous quartzite of Pre-Cambrian age, the inclosing formation being 8,000 ft. The deposit varies in dip, the near-surface part being comparatively flat, whereas the downward extension dips about 23 deg. The orebody is opened up along the strike at the 3,900 level for 5,000 ft., but is divided into north and south units, joined by a lower-grade section in which iron sulphides predominate. Almost all the ore is massive sulphide (7 cu.ft. to the ton), in which galena and marmatite are associated with pyrrhotite and smaller amounts of pyrite, magnetite, and jamesonite (lead-antimony sulphide), with minor quantities of gangue minerals—garnet, diposide, actinolite, biotite, and calcite. The footwall is sharp, but the hanging wall is irregular, and upper limits require exploration. Maximum thickness is 265 ft., representing sharp folds in places where the orebody is contorted.

The south end of the outcrop occupies about an acre and does not suggest more than moderate mineralization. Conspicuous are yellow (limonitic) areas, in which are maroon-colored smaller areas. A craggy outcrop, if such existed, has been removed or has caved into the older workings. The surface evidence of the Sullivan orebody is certainly inconspicuous.

The distance on the dip from outcrop to 3,900, or adit, level intersection is about 3,000 ft.; vertical depth is about 850 ft. Total development openings to the end of 1930 aggregated 120,982 ft. or approximately 23 miles. Drifting during the last few years averaged about 4,300 ft.; crosscutting, 1,250 ft.; and raising, 4,300 ft. per year. Much diamond drilling is done, about 11,000 ft. per year.

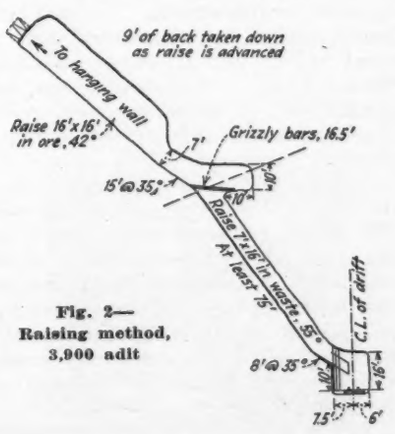


Fig. 2—Raising method, 3,900 adit

At this property, the development plan is simple. A 10x12 adit, 7,100 ft. long at an altitude of 3,864 ft. (called the 3,900 level) extends northerly from a portal above Mark Creek to an intersection with the deposit. A drift extends along this horizon. Two main crosscuts extend into the footwall, and from them parallel footwall drifts, 200 ft. apart, north and south, are driven, from which raises and ore transfers are extended to the orebody. A skipway on a 45-deg. incline connects one of the crosscuts on the 3,900 level to the 4,500 level, a winze connecting the latter with the 4,600 adit level. The skipway, providing a manway and two skipways, is separated by 20 ft. of rock from ore and waste-rock transfers serving all the levels from the 4,500 to the 3,900. A shaft 100 ft. deep connects the 4,600 level with the surface. The 4,600 adit formerly served as an outlet for the upper workings.

Intermediate levels are at 4,400 and 4,250 ft. Footwall development on the 3,900 level occupies a zone about 1,300 ft. wide. Average cover is about 1,000 ft. The country rock, quartzite, is strong and hard, so most of the development openings and all of the stopes require no timbering. The main adit is supported by 12x12-in. reinforced-concrete posts, with caps consisting of two 12-in. I-beams protected by acid-resisting paint. The 10x12 section gives an 8-ft. clearance. It is fireproof, and as so little timber or other combustible is in the mine, the fire risk is a minimum. Drifts, 9x9 in section, give 7 ft. 6 in. clearance.

Square-set timbering was used in the upper adit level early in the history of the mine, but subsequent experience showed that this support was unnecessary, so the deeper areas of the mine were worked with open stopes separated by pillars of ore. Pillars first were left more or less irregularly, but systematic mining superseded this practice. Now, the orebody is laid out in alternate pillar

and stope areas, the minimum being 30-ft. squares up to a maximum of 100x 200 ft. The thickness of the orebody influences the dimensions. More recent practice embraces stopes 50 ft. wide by 200 ft. long, with pillar dimensions of the same size. Pillars on an upper 200-ft. strip, measured along the dip, correspond to stopes on the next lower strip. A sectional elevation thus assumes the appearance of a checkerboard. Roof conditions have proved to be satisfactory.

The stopes are started from, and the ore is removed by, incline raises or transfers, which are driven, at 55 deg., at intervals along the footwall drifts; the latter are spaced at 200-ft. intervals parallel to the strike. The raise, 7x16 ft. in cross-section, is timbered (timbers removed on completion), and terminates in a bulldozing chamber partly in the footwall and partly in the ore. Above the grizzly position the transfer is extended for 15 ft. at an angle of 35 deg., and is narrowed down. From this point it is extended without timbers at an angle of 40 deg., 16x16 ft. in section, through the ore to the hanging wall. The transfer between chute gate and grizzly level is divided by an 18-in., heavily reinforced concrete partition, which gives manway space and affords access to the bulldozing chamber. Fig. 2 shows the general arrangement. The bulldozing chamber is 10 ft. high by 24 ft. long and 16 ft. wide. Grizzly bars, 16 ft. 6 in. long, consist of three 100-lb. rails bound together by angles and bolts,

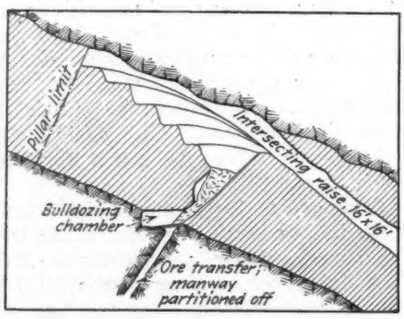


Fig. 3—Method of starting a stope

the angle portions being 12 in. long (½x4-in. angle), which are also bolted to 12x12-in. cross timbers at the ends of the bars. Grizzly-bar spacing is 24 in., with the two outer bars placed close to the sides. Eyebolts are placed in the roof of the chamber for attaching safety-belt ropes.

When the transfer raise through the ore intersects the handling wall, the position of the latter is determined by a series of test holes. A portable diamond drill mounted on a bar or tripod, the heaviest piece being 65 lb., has been devised for testing hanging-wall position. Its depth range is 100 to 150 ft.

A stope is started (Fig. 3) where two transfers from opposite directions meet at the hanging wall. One transfer is used as a manway and the other as an ore transfer. Their position coincides with the end of a stoping portion. The upper portion of the stope is sideswiped along the hanging wall, all of the ore being cleaned off and the back of the stope left in a safe condition. Benches are then taken off from the raise so that the stope assumes a funnel shape with the transfer at its lower point. This is a variant of "underhand" stoping. Vertical bars (12 to 16 ft. long, but seldom over 12 ft.) are used for supporting the drills in sideswiping, and tripods for the drills used in benching. Maximum depth of hole in stoping is 20 ft., the average being about 12 ft.

Two men set up the machines, two machines being used for sideswiping. Holes are placed horizontally. One machine is used in benching, the holes being drilled at an upward angle of 35 deg. in line with the bench. One man is employed in the blockholing for each bench drill. Average footage drilled per shift is 60 ft. and tonnage per machine drill shift is 54 tons. The record is 100 tons per machine shift on straight benching.

Stoping is usually on a contract basis, the contractors buying their own explosives and the company supplying the tools and equipment. Contracts are verbal and may be broken at any time by either party. Day wages are assured and contract prices are adjusted at month ends. Drills used include Ingersoll-Rand N-75, Waugh 17, Chicago Pneumatic 5, and Ingersoll-Rand pluggers. All machines are "wet" machines except pluggers. For raise work, Ingersoll-Rand 51 stopers, wet, self-rotating, are in use. Van Campbell Laird vanadium drill steel, 1¼ in. hollow round, is employed. Experiments with smaller-diameter steel will probably lead to its adoption.

As the back of the stope is a critical feature, only the best miners are employed in opening up. A special crew of twenty barmen, who receive higher pay and a bonus, are employed to make backs and pillars safe, to make periodical inspections, and to take down any dangerous backs that might develop. Special ladders (2x4-in. sides, 16 ft. long, selected straight-grained lumber) are used for this service. To reach high backs, ladders are spliced together, as many as four, and are guyed from four sides. Ladders for this service are painted red. A stairway is used in 40-deg. raises and in stopes where continual travel is necessary.

Development is two or three years in advance of mining. On the day shift 300 miners are employed, with 200 on the afternoon, and 25 repair men on the third shift. Production, 5,600 tons per day, continues for six days, Sundays being used only for emergency work. From 50 to 60 machine drills are worked each shift, including the machines on development work.

By the method of underhand stoping to transfers (glory-hole mining), and by developing stopes 50 ft. wide with pillars 50 ft. wide between stopes, the plan is to win 50 per cent of the ore at first mining. Then by cutting through

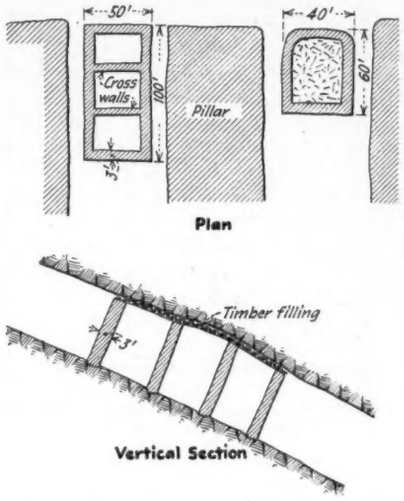


Fig. 4—Method of building reinforced concrete roof supports, preparatory to mining pillars

pillars, the pillar support is expected to be reduced to 18 per cent of the original ore area, thus indicating about 82 per cent of the ore won by the first opening and the pillar cut-throughs. Much of this will be handled by transfers extended from the raises. Remnant pillars will be regularly distributed; their roof load will be five times the load supported by unmined areas. The ore is heavy and is strong enough to carry an immense load.

Mining of remnant pillars presents an interesting problem. The preliminary work is being started in the upper parts of the ore area. The first experiment includes the construction of hollow and filled reinforced-concrete structures placed in the empty stopes between pillars. Two such structures are now in place. One is 40x60 ft. with rounded ends as shown in the plan, Fig. 4; the other is 50x100 ft. in area, divided by two partitions. Walls of these structures are 3 ft. thick, heavily reinforced. One has been rock-filled. Six inches of timber, wedged in between the top of the concrete wall and hanging wall, is expected to provide for a gradual taking up of the weight as the neighboring pillars are removed. The outcome of these experiments will be of much interest. Various methods for mining the pillars, such as top-slicing and sublevel stoping, are being considered. Likewise, a general plan for waste-rock filling is also under consideration.

Mining to the beginning of last year accounted for over 10,080,542 tons, representing about 90,725,000 cu.ft. of excavation. I do not know the average ore thickness; but, assuming this to be 80 ft., the mined-out area would approximate a rectangle 1,000x1,134 ft.

This would seem to indicate that mining is becoming of greater and greater importance in the area above the adit pillar.

Steps are being taken to sink an incline below the adit level and to start development at depth. A diamond-drilling program to determine position and thickness of ore below the adit is now under way. In addition, consideration is being given to the location of a shaft. In effect, a ten-year program is in the making.

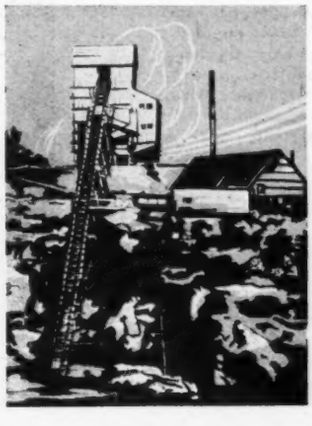
Development

Drifting crews consist of four men. Two work on the day shift mucking out and setting up horizontal bars and beginning drilling. The afternoon shift completes the round and blasts. A 9x9 drift in quartzite requires an 18-hole V-cut round; a 9x10 drift in ore requires a 24-hole round. Depth of round is 5 ft. Contract prices are from $9 to $12 per foot. Two vertical bars are used in raising, raise rounds consisting of 18 to 24 holes. Two shifts are required for each round. In raising, contracts are from $14 to $16 per foot, including necessary timbering. Transfers in ore, without timbering, are contracted, at $11 to $12 per foot. Mucking machines—Armstrong, Hoar, and Butler—are used in drifts and crosscuts. A crew of two or three men, usually two, mucks two drifts in a shift, about 800 cu.ft. Three scraper units are in use for ore handling where stopes reach the footwall. The scraper is of the reversible type, operated by a double-drum hoist. The units are heavy. Footwall scraping is reduced to a minimum and as large a proportion of the ore is handled by gravity through transfers as possible.

Some blockholing is done in the stopes, but most of it at the bulldozing chambers, where the oversize ore is blockholed to pass a 24-in. grizzly bar spacing. The chute-and-gate structure at the transfer loading points is shown in Fig. 5. The drift dimensions are increased to 13½ ft. wide and 16 ft. high at each chute point. Chute bottoms slope 35 deg. for 8 ft., and then connect with the 55-deg. slope of the transfer raise. Ore movement is controlled by a swinging check gate, 18 to 24 in. by 4 ft. 8 in. This is prevented from swinging outward by two heavy angles bolted to the 12x12-in. uprights. Also a lower gate operates in a slot in the bottom of the chute trough. The outlet gate, heavily armored and reinforced with heavy rails, is operated by an air cylinder, 12 in. in diameter, mounted on trunnions and controlled by a four-way valve. This, an unusual type of gate, superseded an undercut arc gate with loading platform. Its inner surface and top are protected by ¾-in. plates. Some of the details are given in Fig. 5, based on the company's drawing 161,772. Life of chute structures is 400,000 tons; some have passed 700,000 tons, and some have been replaced at 200,000 tons. Cylinder replacements since 1926 total five.

Cars of the Granby type (6-ton, 82 cu.ft.) in 30-car trains are used for transportation. Three crews per shift, each consisting of two motormen and two chute men, operate the ore trains. Trolley-type locomotives, 10- and 12-ton, used tandem, haul loaded trains 1½ miles to the coarse-crushing plant near the portal of the adit, where they are dumped automatically. By a system of sampling, train loading is controlled so as to establish an even ore grade for the mill. Variations of over 1 per cent from normal in either lead or zinc are avoided.

Two storage-battery locomotives, Jeffrey and General Electric, as well as two Mancha "mules," are used for auxiliary service on levels. Cable reels are used wherever possible. Motor-generators supply 250-volt direct current for the trolley system. Four units are underground (two units at the portal) and receive current through a cable brought down through a diamond-drill hole. Three 3-in. diamond-drill holes carry 2,200-volt cables for power service.



A Westinghouse electric furnace is installed at one of the principal underground stations on the adit level, and two Ingersoll-Rand drill sharpeners, for completing a drill-sharpening shop, were being placed at the time of my visit. It is planned to handle all drill steel underground at this shop. The use of the electric furnace removes one of the principal objections to underground tool-sharpening shops. Experience with such a shop will be of general interest.

Miners use acetylene lamps, but a storage-battery hand lamp is used by barmen, bosses, and miners for examining working places. The lamp, with large reflector, is of sufficient power to illuminate a great area. It is an important accessory. Adits, drifts, crosscuts, and stations are electric lighted. Drinking water is supplied through a diamond-drill hole. All other water supply is derived from dead ends dammed up to serve as reservoirs. Natural ventilation is supplemented by a 50-hp. 90,000 cu.ft. fan on the surface at the ventilating shaft, but it is operated only in summer. This makes the adit an incast throughout the year. A surface automatic telephone system is extended underground, supplemented by a magneto-type telephone line.

Surface plant consists of shops, change room and office building, compressor building, and the coarse-crushing and loading bin unit. Compressor capacity totals 20,000 cu.ft. per minute, the units comprising two Ingersoll-Rand direct motor-driven compressors, two Nordbergs, two Bellis & Morcom, vertical type, and a rope-driven Canadian Rand. Air receivers are outside of the building, and 10- and 8-in. mains deliver the compressed air to the mains in the adit.

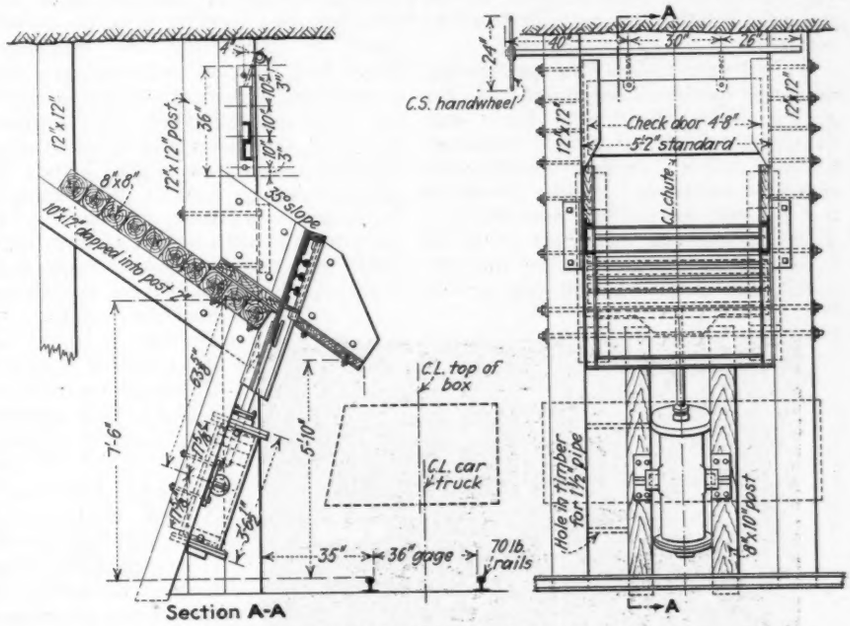


Fig. 5—Standard air-operated chute gate

(The Kimberley concentrator will be described in Mr. Young's next article)

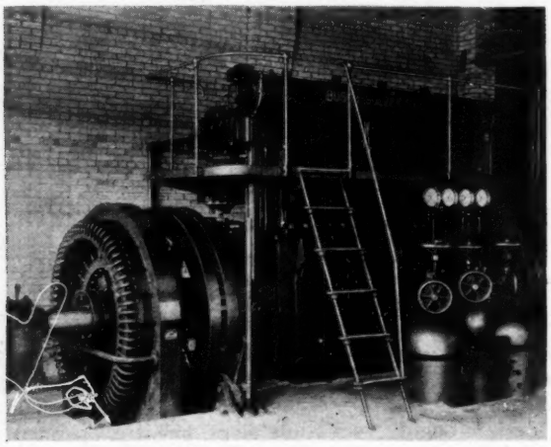
Internal-Combustion Engines in the Mining Industry

[PART I]

A. H. Hubbell
Associate Editor

MUCH has been heard of the extent to which the internal-combustion engine is used in the mining industry, particularly the Diesel engine. Ask anyone how great that use is, and immediately a far-away look comes into his eyes and his answer is vague and indefinite. Handbooks afford no help, as one might expect. The application of engines of this general type to mining is much too recent for handbooks, which take years to compile, to be talkative on the subject. Another reason is that the information is not easily obtained.

A few months ago this publication, desiring specific information on the subject, found how little there was available. Existing mining literature afforded various articles dealing with internal-combustion engine operation and the cost thereof, but nowhere save in one article was the extent of use of such engines in the mining industry specifically discussed, and that article considered the Diesel engine only, dealing principally with certain conspicuous installations. The desired information was evidently to be had solely by investigation.



This Type F, 4-cycle Busch-Sulzer Diesel engine is said by the makers to be their most modern type. One, developing 265 hp., is used by Union Gold Mining Company Atlantic City, Wyo.

If one only knew the mining companies that at some time or other in the last fifteen years or so had seen fit to install engines burning hydrocarbon fuels, the task of getting the desired information would be greatly simplified. But this happens to be one of the principal points to be determined by investigation. Obviously, by visiting mines, mills, and smelters at random one would disclose only a part of the total horsepower, and that with difficulty and expense. Therefore, the desired information was sought by mail. Worked overtime as the questionnaire is in industry today, an investigator hesitates to resort to it. In the present instance, however, there was no alternative.

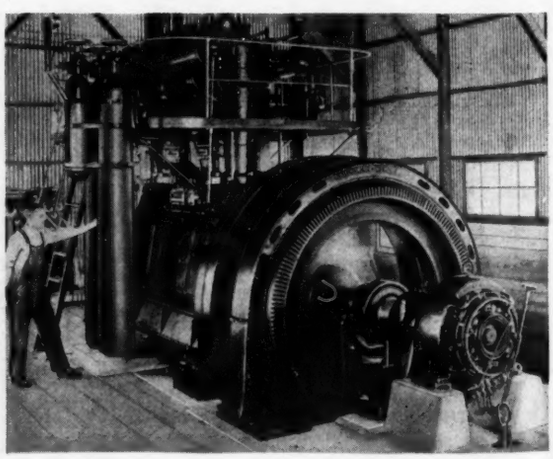
At first only the manufacturers of internal-combustion engines were approached, this seeming to be the easiest route of discovering the companies which had installed such engines. But a surprising percentage of engine builders could not tell where their engines had gone, their output being distributed through jobbers, mine-supply houses, or other secondary channels. Some notable exceptions there were, of course. Inquiry of the distributors yielded little better results. One would think that such records, carefully kept and easily available, would be desirable to anyone in the business. So the investigator was compelled to approach the mine operator directly.

In Table I are presented the data derived, directly and indirectly, from this investigation. The figures, estimated by this survey, represent the total horsepower of Diesel, semi-Diesel, and gasoline engines installed by metal and non-metallic mining companies in the United States (excluding Alaska and insular possessions) and Canada. The questionnaire, by means of which the data were derived, was sent to approximately 2,750 mining companies in the two countries. Metal and non-metallic mining operators of all classes were included, the only exceptions being those engaged in producing petroleum, natural gas, and coal.

With some exceptions, the companies reporting the use of gas engines were in the Tri-State district. No estimate as to this type of engine was therefore attempted. The next few years will probably see a great increase in the use of such engines in the mining industry, for reasons to be discussed later.

For the purposes of this survey the total number of mining companies in the United States was assumed to be only half of those given in Bureau of Mines reports, this halving being done deliberately to allow for possible dismantling of plants—no doubt an excessively large allowance. Possible new plants, or additions to existing plants, were ignored. All things considered, the estimate made is believed to be conservative and reasonable. If anything, the totals given for the horsepower in the first three classifications are probably low.

Horsepower per Company—Of interest are the following factors yielded by the calculations incidental to the survey: Metal-mining companies in the United States using Diesel engines had 543.1 hp. per company on the average, the large units of the Phelps Dodge Corporation and the Commerce Mining & Royalty Company being omitted in the calculation. Semi-Diesel-engine horsepower averaged 215.7 hp. per metal-mining company (in the United States) using such engines, and gasoline engine



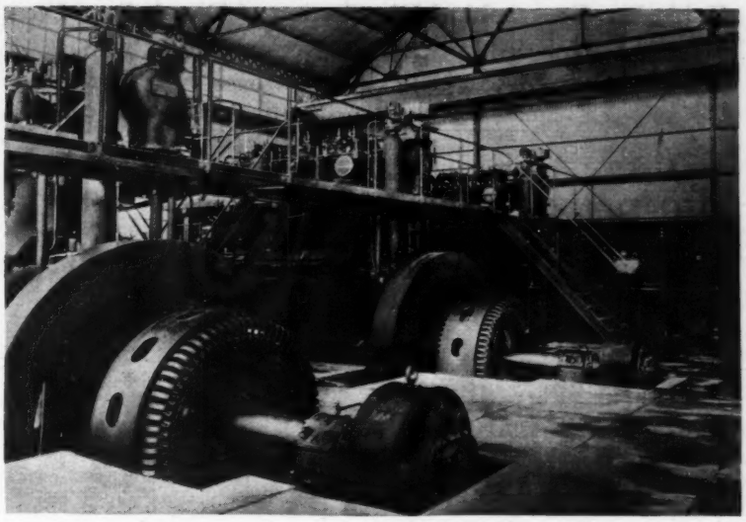
A 285-b.hp. McIntosh-Seymour Diesel engine, driving a 200-kw. 60-cycle a.c. generator furnishing power at a Western copper mine.

horsepower averaged 106.15 per company.

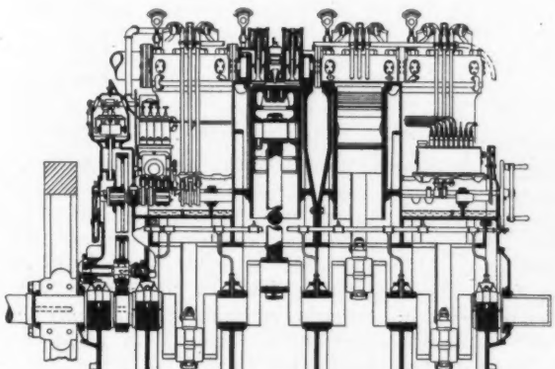
The corresponding factors for the non-metallic mining industries were somewhat different. Diesel horsepower averaged 626.3 per company using internal-combustion engines; semi-Diesel horsepower, 122.9; and gasoline horsepower, 88.8.

Mining companies in Canada, including metal and non-metallic, that were using Diesel engines, had 386.5 hp. per company, on the average. The average semi-Diesel horsepower per company using it was 218.4, and the average gasoline horsepower user was 116.1.

Preference as to Usage — Of the metal-mining companies reporting the use of internal-combustion engines, 42.1 per cent were using Diesel engines; 45.6 per cent, semi-Diesel engines; and 22.8 per cent, gasoline engines. These percentages add up to more than 100 because of overlap, some companies using two of the three types or perhaps all three. The corresponding percentages for the non-metallic mining companies reporting the use of internal-combustion engines are 20, 21.8, and 69.1, respectively. Thus this seems to indicate a relatively greater popularity in the use of the gasoline engine in the non-metallic mining industries.



Two 3-cylinder and one 4-cylinder, Worthington vertical 4-cycle, air-injection Diesel engines, installed in power plant of Erupcion Mining Company, Los Lamentos, Chihuahua, Mexico



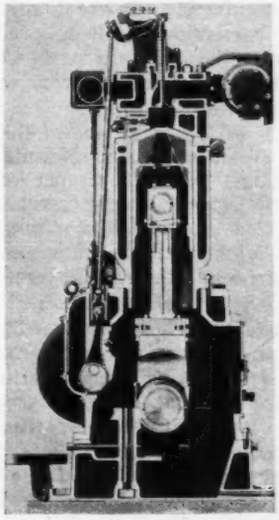
Sectional front view of a Chicago-Pneumatic RH 75 (75-hp. per cylinder) Benz Diesel engine, such as is used by Christmas Copper Company, Arizona. This is a vertical, 4-stroke-cycle, solid-injection, single-acting unit, and is built in 3-, 4-, 5-, and 6-cylinder sizes.

Of the metal and non-metallic mining companies in Canada which reported using internal-combustion engines, 27.6 per cent were using Diesel, and, coincidentally, the same per cent approximately were using engines of the semi-Diesel type. Over half, or 53.4 per cent, of those reporting use of the engines considered, were using gasoline power.

Of the Diesel and semi-Diesel engines (units) reported in mining service 67 per cent were of the full-Diesel type. Writing with reference to United States industry in general, Morrison and Cates, in a paper[1] presented at the World Engineering Congress in Tokyo in 1929, say: "Semi-Diesel engines are rapidly disappearing, for most of the builders are raising compression pressures sufficiently to make the engine cold-starting. For such work as irrigation, cotton ginning, and pumping, when the load conditions are not too severe, these cheaper engines still find wide application." Elsewhere, they say: "Marked development in American engines since 1920 has occurred in the solid-injection, or, as it is sometimes termed, compressorless injection." Of the units with respect to which the type of injection was specified by companies answering the questionnaire, approximately 48.5 per cent used air injection, and the remainder, airless.

[1] "American Developments in Diesel Engines," L. H. Morrison and E. J. Cates.

Geographical Distribution—In Table II is shown, in percentages, the geographical distribution of the Diesel, semi-Diesel, and gasoline engine horsepower reported by metal-mining and non-metallic mining companies in the United States. The 38,400 hp. Diesel horsepower installed in plants of the Phelps Dodge Corporation, in Arizona, and the 10,750 Diesel horsepower in the Commerce Mining & Royalty Company's plant at Cardin, Okla., were ignored in preparing this table. The reader should understand that the information avail-



A cross-section (from flywheel) of a 17¾x22-in. Type PR, solid-injection, vertical Diesel engine, said by Ingersoll-Rand, the maker, to be probably the most popular of its models for mining service. It is made with 3, 4, and 5 cylinder.

Table I—Combustion Horsepower in Metal and Non-metallic Mines in the United States (Excluding Alaska) and Canada

Estimated by Survey

	1 Diesel	2 Semi-Diesel	Total 1 and 2	3 Gasoline	4 Gas	Total 1, 2, 3, and 4
U.S. metal mines	114,346	28,040	142,386	6,897	10,190(a)	159,473
U.S. non-metal mines	109,620	23,624	133,244	56,662	(b)	189,906
Total U. S.	223,966	51,664	275,630	63,559	10,190	349,379
Canada	74,209	41,932	116,141	43,190	.....	159,331
Total U. S. and Canada	298,175	93,596	391,771	106,749	10,190	508,710

(a) Actually disclosed; (b) No estimate.

Table II—Geographical Distribution of Diesel, Semi-Diesel, and Gasoline-Engine Horsepower Reported by Metal and Non-Metallic Mining Companies in United States

Percentages Under 1% Not Reported

	Diesel, Per Cent of Total H. P. Used By			Semi-Diesel, Per Cent of Total H. P. Used By			Total Diesel and Semi-Diesel	Gasoline, Per Cent of Total H. P. Used By		
	Metal Mining Companies (a)	Non-Metallic Mining Companies (a)	All Companies (a)	Metal Mining Companies (a)	Non-Metallic Mining Companies (a)	All Companies (a)	All Companies (a)	Metal Mining Companies (a)	Non-Metallic Mining Companies (a)	All Companies (a)
Alabama	.....	.....	.....	.....	.....	.....	.....	57.96	.....	10.11
Arizona	35.50(b)	.....	19.67	.....	.....	.....	14.61	.....	.....	.....
Arkansas	.....	1.56	.....	2.06	2.57	2.20	1.06	.....	1.22	1.01
California	.....	24.07	11.73	10.30	18.64	12.45	11.94	2.42	15.28	13.12
Colorado	.....	.....	.....	.....	.....	.....	.....	.....	1.88	1.56
Connecticut	.....	1.50	.....	.....	.....	.....	.....	.....	1.89	1.62
Delaware	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Florida	.....	22.27	10.03	.....	.....	.....	7.65	.....	5.72	4.77
Georgia	.....	9.73	4.37	.....	2.47	.....	3.44	.....	1.51	1.26
Idaho	3.36	.....	1.86	3.70	.....	2.61	2.04	9.70	1.63	2.97
Illinois	.....	.....	.....	.....	3.83	1.13	.....	.....	1.81	1.50
Indiana	.....	.....	.....	.....	.....	.....	.....	.....	1.63	1.36
Iowa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kansas	2.28	9.82	5.64	1.71	8.68	3.75	5.17	.....	8.70	7.27
Missouri	.....	6.07	2.72	6.86	6.20	6.68	3.68	.....	1.67	1.39
Oklahoma	(c)	.....	(c)	14.03	.....	9.89	2.53	.....	1.63	1.36
Kentucky	.....	3.31	1.48	.....	.....	.....	1.10	.....	1.73	1.44
Louisiana	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maine	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maryland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Massachusetts	.....	.....	.....	.....	.....	.....	.....	.....	1.63	1.37
Michigan	7.73	.....	4.28	.....	3.09	.....	3.42	.....	1.63	1.37
Minnesota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mississippi	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Montana	.....	.....	.....	.....	.....	.....	.....	.....	1.63	1.37
Nevada	38.50	15.59	28.46	28.10	21.04	26.20	28.23	8.50	13.10	12.35
Nebraska	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
New Hampshire	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
New Jersey	.....	.....	.....	.....	.....	.....	.....	.....	4.27	3.55
New Mexico	1.58	.....	.....	11.55	.....	8.25	2.73	.....	.....	.....
New York	.....	2.38	1.07	.....	.....	.....	.....	.....	2.84	2.37
North Carolina	.....	.....	.....	1.28	6.04	2.73	.....	.....	.....	.....
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ohio	.....	.....	.....	.....	26.24	7.86	1.99	.....	8.20	6.85
Oregon	.....	.....	.....	.....	.....	.....	.....	2.42	.....	.....
Pennsylvania	.....	.....	.....	.....	.....	.....	.....	.....	2.66	2.22
Rhode Island	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
South Carolina	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
South Dakota	.....	.....	.....	18.40	.....	13.20	3.33	.....	1.63	1.36
Tennessee	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Texas	.....	.....	.....	.....	.....	.....	.....	.....	1.64	1.36
Utah	.....	.....	.....	.....	.....	.....	.....	.....	4.83	4.04
Vermont	.....	1.84	.....	.....	.....	.....	.....	.....	1.38	1.15
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	1.99	1.66
Washington	5.35	.....	2.96	.....	.....	.....	2.38	17.00	.....	2.82
West Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wisconsin	.....	.....	.....	.....	.....	.....	.....	.....	1.99	1.66
Wyoming	1.99	.....	1.09	.....	.....	.....	.....	.....	1.63	1.36

(a) Percentages under 1% are not reported. (b) Excluding Phelps Dodge Corporation. (c) Commerce Mining & Royalty Company omitted.

able for this compilation was limited to that supplied by the mining companies themselves. Those that, for one reason or other, furnished no information were of necessity left out of consideration. The percentages given are therefore subject to correction. It is believed, however, that the distribution shown is on the whole approximately representative of the existing situation.

Study of Table II shows that, with the omissions cited, Nevada leads the states with 28.46 per cent of the total Diesel-horsepower reported by metal and non-metallic mining companies in the United States, and with 26.2 per cent of the total semi-Diesel horsepower. Of the combined Diesel and semi-Diesel horsepower it has 28.23 per cent. Of the gasoline horsepower reported by mining companies the state has 12.35 per cent, being a close second to the leader, California, which has 13.12 per cent.

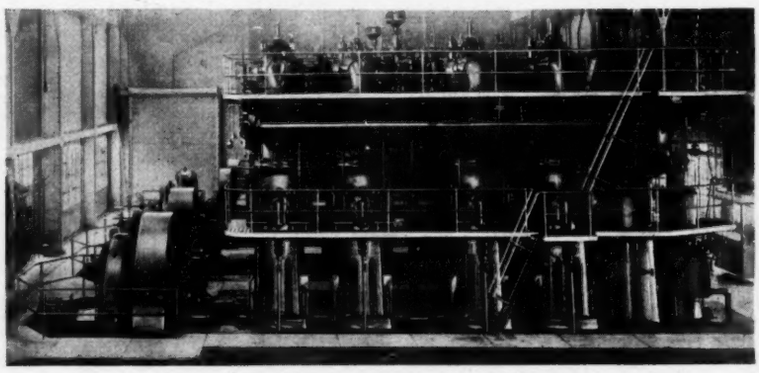
Despite the omission of the 38,400 Diesel horsepower, installed by the Phelps Dodge Corporation, from the calculations, Arizona has 35.5 per cent of the Diesel horsepower reported by metal-mining companies, this being equivalent to 19.67 per cent of the total Diesel horsepower reported by all mining companies. As previously stated, the 10,750 Diesel horsepower of the Commerce Mining & Royalty Company, installed at Cardin, Okla., was also omitted from the calculations.

Manufacturers—Of the total Diesel and semi-Diesel horsepower disclosed in the United States, 94 per cent was credited to engines made by seventeen manufacturers, and 89.4 per cent to the engines of six manufacturers. The names of the makers of the engines furnishing 6 per cent of the total horsepower were not divulged. For illustrating this article, including Part II, which will appear in a later issue, views or drawings of Diesel and semi-Diesel engines built by twelve of these manufacturers have been selected for examples.

Thirty-three manufacturers supplied the gasoline engines disclosed in the United States by the survey, the total horsepower being fairly evenly distributed among them. Only a few of these were also builders of Diesel or semi-Diesel engines.

The next and concluding installment will deal with fuel costs, with the comparative advantages of the Diesel and semi-Diesel engine, and with applications, and size of units. It will also refer briefly to prospective expansion in the use of natural gas.

(*To be concluded*)



Nordberg Diesel engines, in plant of Phelps Dodge Corporation, Bisbee, Ariz.

Survey Lines for Drift Curves

George A. Clayberg

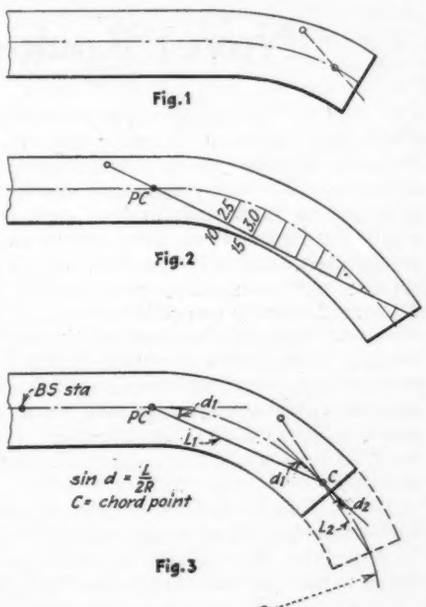
Beatty, Nev.

TO PUT IN lines for a drift curve that will not cause him too much trouble and, what is perhaps more important, will suit the miner in every respect, is always a problem for a mine surveyor. The miner is the one who is to run the curve, and he must have definite information by which to drill. This must be furnished him by a good system of lines, as the engineer cannot usually be present more than a short time each day.

A miner drills his best round when he can set up the machine for his first hole—the top center—in the actual center of the drift; collar the hole on the face center, marked from the engineer's lines; and line up the machine itself for direction by sighting the lines and the machine. This procedure gives most accurately the center of the next face. At the same time it gives the correct direction to the drift, because an experienced miner can easily judge his round once the center hole is drilled He usually leaves a steel in the hole and points his other holes by it.

In the event that the engineer puts in lines which hit the face considerably off its true center, as is often the practice of an engineer who does not understand, or care about, the miner's side of the question, the miner is led into all sorts of trouble. This usually reflects on the engineer, who, in turn, blames the miner for a poor curve which really resulted from his own lack of understanding of the miner's difficulties. An exception to this practice is the offset system of drift curve lines, which are not actual direction lines but only a convenient means for marking center; this system will be considered later in this paper.

Suppose that a miner has been given lines by which to drill his round that hit the face, say, a foot or more off its center, as in Fig. 1. He has the choice of two alternatives. He may set up, as already described, in the middle of the drift; collar his round, centered with respect to the present face; and make a guess at hitting the center of the next face. The face of the blasted round may have the correct center, but the direction of the drift and that of the walls are likely to be off. This is a cumulative error, which may not be noticeable in the first round, but which will cause trouble later, because a miner drills his round largely by comparison with his last drift walls, even on a curve. Once the drift walls are off with respect to the theoretical center line of the curve, much more trouble is involved in bringing the drift back on line than would be required to keep it there in the first place. Moreover, a crooked curve results. As his other alternative, the miner may collar his round off the center of the face, but on the engineer's center, and line his machine with the lines. With this method he has cramped quarters for the operation of the Leyner; he cannot break nearly the footage of his customary round, which is important to a contract drifter; and the best miner will leave a bad break in the drift walls. Further, several of the holes must be drilled with the machine at a slant to the crossbar. To keep the machine lined with the steel during this drilling is difficult.



Sketches of survey methods

The best lines for a drift curve are, therefore, those that give the direction of the next round and hit the center of the present face. However, if the first qualification were put into practice, the engineer would have to give lines for the curve every round, which would take too much of both his time and the miner's. All who have gotten in the way of a contract miner for any length of time will know how important that consideration is.

Lines every round could be given more easily if the miner be on night shift, but the resulting accuracy achieved is seldom required, and new lines every three or four rounds are usually sufficient, depending on the amount of curvature. If a good miner is given an accurate start on a curve, the consistency with which he keeps the degree of curvature is surprising.

Two systems of lines for drift curves are in general use. One is the offset method, which was used by the United Verde Copper Company, at Jerome, Ariz., when I was employed there as an assistant underground engineer. The other is the system of chords and deflection angles, which may be applied to mine drift curves in several different ways.

The offset system consists of putting in a line at the point of curvature of the drift center line at as great an angle with the latter as will clear the inside drift wall of the future curve, as illustrated in Fig. 2. The center of the face is marked each round by measuring perpendicular offsets from this line. A chart of the drift curve is made, to scale, with the desired width of drift and radius of curvature. On this chart a line is drawn through the point of curvature that will clear the drift wall, and the angle that the line makes with the present drift center line is measured. This line is then put in underground, in the usual manner, by setting up the transit at a station that has been set at the point of curvature, turning the measured angle, and putting in a backline plug for this new line. The line is spotted on the face each round by sighting the plug and station; the distance to the face measured; and the chart consulted for the proper offset distance to the center from the line spot, corresponding to the distance to the face from the point of curvature. This enables the engineer to mark the correct location of the face center in a few moments each day. When the line hits the outside wall a new line may be put in that essentially repeats the process.

Manifestly, the advantage of this method is the saving in time that is effected. However, it gives the miner only the location of the center and not the direction that he must follow. A drift miner much above the average is required to put the drift where the engineer wants it. According to my experience, about the easiest way to start a long argument in broken English with a foreign drift miner is to attempt to explain to him how you want a curve

run by this offset method. Telling the miner to move the center of the face over one foot in the next round doesn't give him a very clear idea of how he is to drill.

The method of chords and deflection angles may be classified under two heads: (1) chords of equal length with equal deflection angles; and (2) chords of variable length with corresponding deflection angles. A Brunton compass may be used with this method where accuracy is not required. Taking the length of a round as the chord, the radius of curvature being given, the deflection angle may be calculated. Standing against the center of the face, the back bearing of the drift may be taken and the deflection angle roughly turned, the direction of the round to be drilled being spotted on the back or wall of the drift. However, where a connection is to be made, or a definite curve is required, the transit must be used.

Under most conditions the method of equal chords is best applied to timbered drifts, in which the sets are kept close to the face. In such instances, the length of a chord is equal to the length of a set, and the direction of each set has a deflection with that of the last, determined by the deflection angle for that chord and the radius of curvature used. The lines may be put in conveniently on the caps, every set if desired, as no holes have to be drilled and little time is required. With hard rock drifts, this method becomes impracticable for two reasons. First, a plug and spad must be put in at every chord point along the center line of the drift, and to drill a hole in the back at any theoretical point is not always possible owing to the character of the rock. Second, the length of round broken is irregular and seldom conforms with the length of chord chosen, and therefore the chord line seldom hits close to the center of the face, the numerous disadvantages of which occurrence have already been mentioned.

A good method of overcoming this difficulty is to use a chord whose length suits the position of the drift face. The deflection angle is calculated underground after the chord length is chosen. A point is selected as close to the face as will permit setting up the transit, and the distance to it from the station previously set at the point of curvature is measured. Then the deflection angle to be turned at the point of curvature to put this point on the curve center line is calculated by the formula: sine of the deflection angle equals the length of the chord divided by twice the radius of curvature.

The chord point is spotted by angle and distance, with the instrument at the point of curvature; the hole is drilled; and the spad set. Deflection angles are always turned from the tangent to the curve at the instrument set-up. When the set-up is at the point of curvature, the tangent is, of course, the backsight along the straight center line of the drift. The actual angle turned is 180 deg. plus or minus the deflection angle. In Fig. 3, inasmuch as the curve is a right curve, the angle turned will be 180 deg. plus the deflection angle. The transit is then set up at the chord point. To obtain the tangent, turn the same angle that was used at the point of curvature, and, from the tangent, turn a new chord for the drift lines for one round or for as many as desired. This last deflection angle may be calculated roughly, or it may be kept in a notebook for 4-, 5-, or 6-ft. chord lengths or multiples thereof, depending on the length of round drilled. The back-line plug and spad are set on this new line. When the curve proceeds far enough to make the point of curvature invisible from the face, the chord point may be set from the last one.

During my engagement as underground engineer for the Christmas Copper Company, at Christmas, Ariz., I used this method to advantage on several curves of 40-ft. radius, giving the miner a drift line every 15 ft. or every three rounds, the line representing a 15-ft. chord. The lines always hit close to the center of the face, and the miners in these drifts were the first in my experience to be satisfied with the engineer's lines for their drift curves.

■ ■ ■

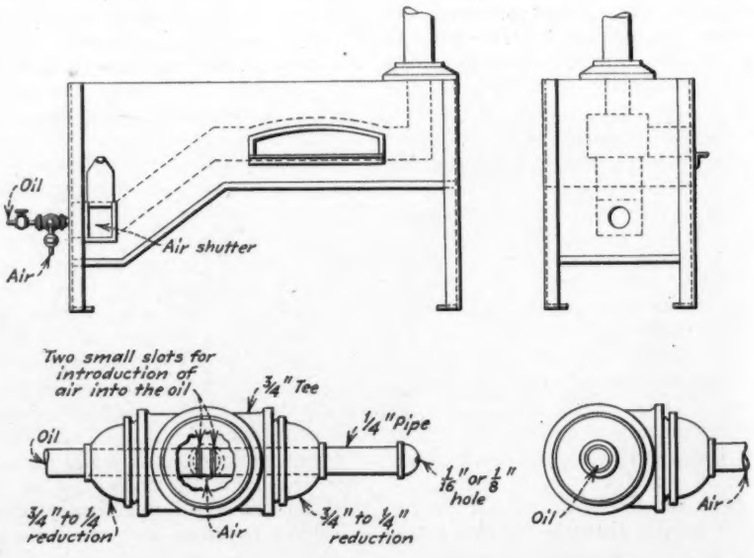
Novel Rock-drill Furnace

SKILLFUL operation of a properly designed furnace is necessary to obtain a superior grade of sharpened drill steel. The fire chamber should be arranged to give uniform heat and a slightly reducing atmosphere, so as to permit slow heating of the steel and to prevent decarbonization and scaling. With mechanically controlled electric or gas-fired furnaces this problem is not serious. The commonly used oil-fired furnace, however, requires considerable attention, when not equipped with a low-pressure steam boiler for injection of steam instead of air to produce what is termed a "wet" flame.

A departure from the usual design of the standard oil-fired furnace has been developed by M. Arballo, at the Las Cuijas mine of the Tungsten Alloys Corporation, Arivaca, Ariz., as shown in the accompanying sketch. Instead of introducing the flame directly into the fire chamber, the burner is placed about 16 in. below the chamber floor and connected to the fire chamber by an inclined tunnel. This avoids direct exposure of the drills to the flame and prevents excessive heating, besides providing a constant uniform heat in the fire chamber without material heat losses. To improve combustion further, air may be admitted to the burner chamber through an adjustable shutter at the burner end of the furnace.

An additional feature is the design of the home-made burner, built on the principle of a "closed" Diesel injection valve, which has given excellent results. As shown in the illustration the burner consists of a $\frac{3}{4}$-in. "tee," traversed by a $\frac{1}{4}$-in. nipple and valve. Compressed air, entering through two slots cut in the horizontal oil line with a standard hacksaw blade, forces the oil in the form of vapor through the atomizer, which consists of a small steel cap with a $\frac{1}{16}$-in. to $\frac{1}{8}$-in. hole on the end of the oil line.

The furnace shell is made of $2\frac{1}{2}$-in. angle iron and $\frac{1}{8}$-in. plate; standard refractory brick is used for the lining.



Open-Stope Methods of Mining

Morris J. Elsing
Mining Engineer and Geologist
Tucson, Ariz.

CONSIDERABLE difference of opinion exists as to the best classification of stoping methods. Most classifications are based upon the method of breaking the ore—that is, by breast stoping, overhand stoping, and underhand stoping. According to this classification, inconsistencies immediately appear: as, for example, in mining a thick, horizontal bed by open-stope methods. In this operation, the upper portion, immediately under the hanging wall, is mined by breast stoping, and the lower by benching or underhand stoping. Sublevel stoping combines all three methods of breaking, with underhand and overhand work in equal proportions and with breast-stoping somewhat less. The modern methods of breaking ore in shrinkage, cut-and-fill, and square-set stopes is by breast-stoping rather than by the older overhand method, and yet these stopes are classed as overhand stopes.

The terms breast-stoping, overhand stoping, and underhand stoping have become obsolete as the basis for the classification of stoping methods. Their use should be confined as descriptive of the method of breaking ore but not of the method of stoping. Thus, we have the overhand shrinkage method and the breast-stoping shrinkage method, and, similarly, we have underhand square-set stopes, overhand square-set stopes and breast square-set stopes.

I believe the simpler we keep the classification the better. To me, it seems, there are six distinct underground methods of stoping as applied in metal mines. Every other method is a modification of one of these. They are as follows: 1, Square-set methods; 2, Top-slice methods; 3, Cut-and-fill methods; 4, Shrinkage methods; 5, Open-stope methods; 6, Caving methods.

Open Stoping—In open-stope mining there is considerable variation. The generally accepted definition of an open stope is one from which the ore is taken out and the stope is left open. Where support is necessary, pillars of ore are left at regular or irregular intervals. Occasionally stulls or waste-rock cribs are used.

Open-stope mining is the oldest of underground stoping methods and one of the most important in point of production. Its use is universal, but it is most highly developed in the United States. So much has been written about it that the following discussion will be confined to certain particular features of the method. Nearly all open-stopes can be divided into one of four main groups and in all instances the methods of stoping are radically different in one or more respects. The four groups are: 1, Horizontal beds or veins; 2, Flat incline beds or veins; 3, Narrow steep incline beds or veins; 4 Larger orebodies, veins or deposits, flat or incline.

Horizontal Beds—The orebodies in the Tri-State district, in Southeast Missouri, and in the Wisconsin zinc district are characteristic in that they are generally flat and of large horizontal extent. They occur at shallow depth, and usually the hanging wall stands well. Generally the ore is not hard. Such conditions are ideal for open stoping. Ore is broken by breast stoping or, where the body is sufficiently thick, the upper part is mined by breast stoping and the lower portion by underhand stoping or benching. The combined method of breaking and benching is the more efficient both from the standpoint of breaking the ore and of shoveling. Mechanical shoveling under this condition is quite effective, and scrapers also can be used to better advantage. However, most operators in the Tri-State district consider that shoveling by hand into cans is the most economical method of loading. Such a condition can be possible only where ventilation is almost perfect. The condition of the mine air affects the rate of shoveling to a greater extent than it does any other operation in mining. Air conditions also affect hand shoveling more than do any of the other conditions under which shoveling is done. One of the advantages of open stoping is that good ventilation is easily obtained, especially where the mine workings are shallow, as they are in the districts mentioned.

The main characteristics of this group are that ore can be broken and loaded efficiently and that a minimum amount of development is in waste. These favorable factors are reflected in the cost per ton of mining, which is lower than that of any of the other groups.

Flat Incline Beds or Veins—The Michigan copper mines are representative of the flat incline beds or veins. Stopes are large with irregular pillar support, or are long and narrow with narrow pillars. The orebodies generally have a dip which is less than the angle of repose of the broken ore, and, consequently, cars cannot be loaded by gravity, nor can they be loaded by hand until the ore has been transferred from the working face. This feature is characteristic of flat incline beds or veins as a group. To accomplish this transfer of ore from the stope to the cars several methods are used, which include re-shoveling, metal troughs or slides, and shaking chutes or conveyors. Under certain conditions scrapers can be used effectively in loading.

In this group there are no distinctive features in drilling and blasting except that drilling is nearly always done with drifting machines or jackhammers. Pillars are left systematically near shafts and under levels and often without system in the main stoping sections.

Narrow Steep Incline Beds or Veins—This type of open stope, so to speak, is the common variety and is extensively and widely used. The broken ore drops or slides from the working face to chutes without intermediate handling. Drilling is done with stopers, drifters, or jackhammers. Pillars are left where necessary. This group is distinctive in that timber support must be provided as a scaffolding from which drilling and blasting are done. In some operations this timber is necessary as a support for loose sections of the walls. In the flatter of these steep veins it is possible to drill short holes into the footwall at short intervals, and by inserting into them short pieces of steel, and by resting a plank or timber on the steel, to provide a satisfactory footing from which to do the drilling. Under most conditions a more stable foundation from which to work is necessary, and the most common method is to place stulls at about 5-ft. intervals with good floor boards upon them. The width of vein worked by this method is limited. Long stulls are hard to place, and after they are placed they are more likely to be broken by blasting than the shorter stulls. Two floors of stulls must be in place most of the time.

After the ore has been removed above one floor, a higher row of stulls is put in. When this upper floor is in place, the recovery of stulls below is possible, but is difficult and accompanied with some danger. In fact, all work in such a stope is more dangerous than in most stopes. It is seldom that floor boards are placed securely, because the first placing of them is only temporary. They are put down, the round is drilled, and before blasting is done they have to be removed. All work is done over an open hole which may be a hundred or more feet deep. As with shaft sinking, such an open stope is no place for an awkward man. Miners who are accustomed to this class of work develop a cat-like agility, and the accuracy and speed at which they move about and work are surprising.

Difference of opinion exists as to the

maximum efficient width of vein workable by this method. The maximum stull length is, however, the final limit. My own opinion is that under normal conditions, 5 ft., approximately, is the maximum width for such stoping. If the stope is wider than this, the shrinkage method offers many more advantages. Of course, there are some exceptions to this, one of which might be when stoping a very sticky ore. Shrinkage stoping would not be feasible in that case.

Larger Orebodies, Flat or Incline—At Mascot, Tenn., an underground glory hole or mill hole modification of the usual open stope is used wherever possible. With this type of stoping it is customary to drive a raise into the orebody. Near the top of the ore, mining is started in all directions around the raise. As soon as the opening is of sufficient size, the breaking of ore is done by the underhand method, the ore being blasted so that it will fall into the chute. A sublevel stope is essentially an open stope and, more particularly, a glory-hole modification of open stoping. The main difference between the usual glory-hole stope and the sublevel stope is that the ore in the latter is broken in a more systematic manner through the means of sublevels. In sublevel stopes there is considerable variation in the actual method of breaking the ore. In some instances it is done by underhand methods and in others by overhand methods, but usually the two are combined. Important examples of the sublevel method are found on the Marquette and Menominee ranges, at Fierro, N. M., and at Ducktown, Tenn.

The glory-hole method, including the sublevel modification, is used in widely scattered places, but the tonnage produced by it is only a small part of that broken by the open-stope method. Exceedingly low costs nearly always accompany the use of this method. Powder is effectively used and shoveling is almost eliminated. In some instances, when the ore tends to break in large slabs or boulders, grizzlies must be installed, as blockholding over a grizzly is the cheapest means of breaking boulders. The tonnage handled through a grizzly is large and the cost per ton for grizzly installation is therefore small, being distributed over a large tonnage.

With its sublevel modification the glory-hole method can be applied to a variety of deposits. The ore, as well as the country rock, must stand well. The method is applied most advantageously in larger orebodies, which may be beds, veins, or contact deposits, either flat or incline. Other conditions being equal, lowest costs are obtained where a large tonnage is accessible to one chute or grizzly. This necessitates considerable width of vein (30 or 40 ft.) and a dip of vein that is steeper than the angle of repose of the broken ore. This, however, is not absolutely necessary, inasmuch as at the Mascot mine, where scraping is used effectively in glory-hole stopes, a total direct cost of 65c. per ton, including hoisting and development, is obtained.

No set rules exist for leaving pillars. These may be left between stopes and sometimes they are left in the center of stopes. The matter is determined largely by the particular conditions under which the stope is being worked. In some operations, such stopes are filled by caving the roof over the stope, and the pillar between stopes is then mined. This modification of open stoping, thus briefly outlined, is more or less in a stage of development, but I believe it has a much wider use. Cost per ton by its use is only slightly higher that that of the large-scale caving operations.

Disadvantages of Open-Stope Mining—The open-stope method of mining possesses a serious disadvantage that is sometimes overlooked or often underestimated when its use is decided upon. An excavation underground which is left open is a liability. The seriousness of such a liability depends upon the consequences which might result from the caving of the opening. These are usually dependent upon several factors, among which are the size and shape of the opening, the character of the ground in which the opening is made, and the distance from the surface or the distance from a shaft or other mine working which is being used.

If a small opening caves, the results are not serious usually. A small opening caves gradually and does not give rise to an air blast. Generally, boulders and slabs slough off from the roof, gradually enlarging the hole higher up but filling it below. The rate of filling is more rapid than the rate of enlarging, owing to the increased bulk of the caved material, until finally caving is checked by the caved material. Under certain conditions caving is probably checked when it has gone far enough to cut off the air supply. The subject is too large to discuss at length at this time, and suffice it to say that if caving of abandoned workings takes place in this gradual way loss of life never results.

The greatest danger in caving is caused by air blasts. If one has never seen the results of a real air blast or has not had it vividly described to him, what happens is almost beyond realization. All loose objects, including loaded cars, trucks, wheelbarrows, tools, timber, and boulders, are picked up and hurled through drifts, stopes, and raises as if they had been shot from cannon. Frankly, I am afraid of large open holes underground for more reasons than one. They may stand open for years, but if they are continually being enlarged or if their walls are being weakened by workings in adjacent sections of the mine, some day they will cave. Such a result is inevitable.

Certain measures can be taken which may partly prevent the terrible consequences of a great air blast. If the hole is in the worked-out part of the mine, a cushion of waste can be dumped into it with the idea of sealing off possible exits through which air might escape into parts of the mine which are being operated. Drifts can be sealed off by gobbing and back-filling them to the roof. In other operations, it might be advisable, instead of sealing off the bottom of the hole, to leave open air courses which lead to an abandoned part of the mine and then to the surface. In other words, exits should be provided through which the air can pass where it will do the least damage.

The intensity of the air blast is determined mainly by the rate of caving or the speed of caving rather than by the amount of material that caves. The fall of one large slab will create a greater disturbance than several times the same amount of ground falling throughout several seconds. Similarly, a large stope can cave in, and if it takes several minutes to do so, strong air currents will be set up, but not of air-blast proportions. Caving in this way seals off the lowest openings, and a part of the air may be kept out of the mine. In such circumstances, the highly compressed air works up through the caving material, and if the cave reaches the surface, this air causes a skyward ejection of rock, boulders, and dust. The most severe air blasts are caused by the almost instantaneous closing of the opening. Slips and faults in the stope and the character of the ground undoubtedly have a definite effect upon the rate of caving.

In the Dec. 1, 1928, issue of the *Engineering and Mining Journal*, R. B. Wortley describes the method of caving the ground over large worked-out individual stopes at the Carpenter and Monongahela mines. This is done so that serious consequences do not result. In this way, the continual menace of the natural and the probably simultaneous caving of several stopes, which might easily be of disastrous proportions, is avoided.

The foregoing discussion of air blasts has reference entirely to large open stopes, especially where the vertical dimension is great. Large air blasts never occur in the flat-bebbed deposits, such as those in the lead-zinc districts of the Central States. Caving of such worked-out stopes is never serious save where the surface has valuable uses or in exceptional cases where a body of water exists on the surface.

Study of pillar collapse or pillar failure must end with the obvious conclusion that pillars fail because they are not large enough to support the weight which rests upon them. On final analysis, the proper size of pillars is only a guess.

Many unknown and undeterminable factors necessarily control the size, and to fix a set rule is not possible. In a good many instances pillars have been too small, and their failure has resulted in considerable expense. It seems to me that after failure once starts, the attempt to bind a pillar together with tie rods and to try to hold it together in other ways is at best a makeshift. When failure begins to be evident the only satisfactory alternative is the practically complete filling of the stope.

To a large extent the size of pillar support is an economic consideration. If the ore is high-grade, it might be worth while to risk cutting the pillars to a minimum size, but with low-grade ore such an attempt would be unwise. The ideal condition exists where the surface has no real value and it is possible to trim pillars to a minimum with the expectation that they will provide support only during the period of active stoping operations.

What has been said about large unfilled holes left by open stopes is also applicable to the holes left by failure of the back to break over a top-slice stope or a caving stope and also to the holes left by drawing the ore from a number of shrinkage stopes.

In the struggle to cut costs, the dead work of filling a large hole is often delayed, or the enlarging of an already large hole is permitted beyond safe limits. Usually a large cave gives considera'le warning, and the loss of any considerable number of lives in one accident is rare. In numerous operations, however, improper attention to filling has been the cause of the caving of large areas, with a resultant loss of ore and the loss of shafts, drifts, raises, and other work.

Although open-stope methods are not supposed to require filling, the adoption of the method does entail that eventuality in those operations in which excavations get too large and pillars have been cut down too small. In other words, the adoption of the method not infrequently carries with it the obligation and responsibility of filling, the need of which sometimes does not become apparent until years after the ore has been mined.

■ ■ ■

Determination of Grinding Factors

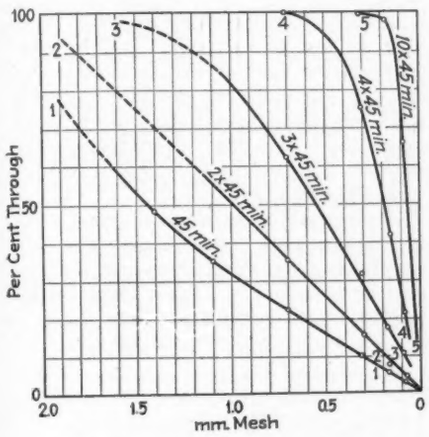


Fig. 1—Screen analyses on quartz

WHEN grinding ore preparatory to tests in an ore-dressing laboratory, a study of the grinding factor, or the resistance to grinding, should be of interest, writes Magne Mortenson, Trondhjem, Norway. Screen analyses of different ores, ground under identical conditions, may be used as the basis for such comparisons. Fig. 1 gives a series of curves for screen tests on quartz, ground under the same conditions for different units of time, 45 min. being selected as the unit. Two curves plotted in Fig. 2, representing tests run in triplicate, show that the results plotted in Fig. 1 are easily reproduced and should be reliable. Samples of Norwegian pyritic ores, ground and screened under the same standard conditions for one unit of time (45 min.), are represented by the graphs in Fig. 3. Comparing the curve for an ore with the curves for quartz, the ore may be referred to the interval between the standard curves n and $(n+1)$. Grinding for 45 min. will reduce this ore to the same size as quartz ground for between n and $(n+1)$ min.

Grinding factors obtained for different Norwegian ores and rocks are as follows: Miscellaneous pyritic ores, 2.5–4; magnetic ores, 3–4; fine-grained granite, 3; gneiss, 3–4; sausorite gabbro, 2.7; soapstone, 8.

Large-scale grinding is generally done in mills with classifiers in closed circuit. In this case a particle of quartz should flow through mill and classifier n times in order to be reduced to the same degree of fineness as a particle of ore with the grinding factor n. As grinding in closed circuit differs somewhat from batch grinding, a special examination should be made to determine the standards for comparison between the two methods.

In the tests the following procedure was used: The ore samples were crushed in a Dodge breaker with a discharge opening of 6 mm. (¼ in.) A product with a particle size of 1.6–2.5 mm. (0.06-0.10) was screened out and used for batch-mill grinding. The mill had a diameter of 250 mm. (10 in.); a length of cylinder of 110 mm. (4½ in.); a speed of 75 r.p.m.; and a charge of 2.1 kg. (4.6 lb.) 45-mm. diam. (1¾-in.) cast-iron balls, 2.1 kg. ore, and 1,000 c.c. water. After grinding for 45 min. the sample was dried and 100-gram portions were cut out for the screen tests.

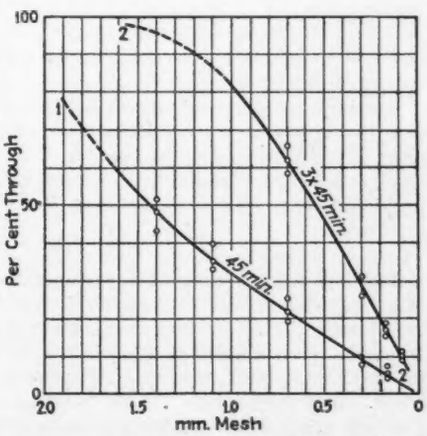


Fig. 2—Test on quartz to determine accuracy of method

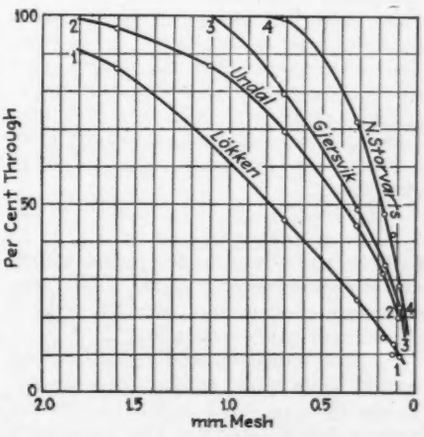


Fig. 3—Screen analysis on Norwegian pyrites

■ ■ ■

Suggested Improvements in Fire Refining of Copper

H. H. Alexander

Westfield, N. J.

THE present method of fire refining copper consists in melting the metal in a reverberatory furnace; removing the slag; oxidizing impurities with air; and removing the excess oxygen from the copper by poling. Though many improvements have been made in recent years in the furnace equipment, few changes in the furnace treatment have been developed.

In melting a charge of copper, the top layers melt first, and the molten copper trickles onto the relatively cold metal and is chilled. This melting and chilling continue until the entire top of the charge is melted, leaving a pool of metal on the surface of the charge. Further melting is accomplished by heating this pool of metal, necessitating a high temperature, which has a destructive effect on the furnace walls and roof, and requires additional fuel. This method of melting not only fails to remove any large amount of impurities from the copper, but may result in adding to them; impurities are thus often added both from the furnace fuel and from the reduction of oxides present in the charge.

In removing impurities from copper by oxidation, an excess of air is used. This oxidizes some of the copper, part of which passes into the slag, and the remainder must be deoxidized. Slag production is considerable, amounting to 1 per cent or more when treating cathodes.

The poles used for deoxidizing are 5 to 12 in. in diameter and from 15 to 25 ft. long, and should be hardwood, green, and comparatively straight. This type of young timber has already become scarce near some refineries.

In both oxidation and reduction, the metal, containing oxides, is splashed on the furnace walls and roof, causing them to erode rapidly. The metal bath is often shallow, a condition unfavorable for the oxidation or reduction operation. A charcoal or coke cover is used during casting to prevent contamination of the copper. This charcoal or coke cover is difficult to spread uniformly over the surface of the molten copper. Even if uniformly spread, it is consumed in spots, thus exposing the metal. The exposed metal picks up impurities, and a product of uniform quality is rarely obtained. Frequently, the last part of a charge must be worked over again to bring it up to standard.

Peters in "Principles of Copper Smelting," p. 485, states of fire refining copper: "This seems like giving with one hand and taking back with the other. As a matter of fact, however, it accomplishes the purpose of getting the copper into a marketable condition quite rapidly and economically, although it is an imperfect operation, and is accompanied by certain drawbacks."

A careful study of the disadvantages of fire refining of copper suggested the possibility of several changes in the usual procedure. The methods outlined are incorporated in United States Patents 1,687,277, 1,756,967 and 1,776,826, all granted to the writer of this article. These changes, which were first tried in the laboratory and then in furnaces of commercial size, follow:

Removing Impurities by Oxidation

Impurities in copper from the same source vary in amount and kind, even in cathodes from the same plant. These variations depend on many conditions, such as the impurities in the anodes, the composition, temperature, and rate of circulation of the electrolyte, the amount of addition agent used, and the thoroughness with which the cathodes are washed.

Though the amount of impurities in cathodes is small, their removal from molten copper presents many problems. Sulphur, one of the most common impurities, is very difficult to remove, and a small amount remains with the copper after most of the other impurities have been eliminated. Its removal requires an excess of air, resulting in the oxidation of some of the copper. The replacement of one impurity by another, even though the impurity last introduced is easier to remove, is of course objectionable.

At temperatures used, steam will oxidize the impurities and remove the sulphur without oxidizing the copper. The sulphur in copper reacts with steam to form sulphur dioxide; the copper is unaffected:

$$Cu_2S + 2\,H_2O = 2\,Cu + SO_2 + 2H_2$$

The free hydrogen resulting from the reaction will combine with any free oxygen present, and so long as sufficient hydrogen is liberated to combine with the oxygen present, no oxidation of the copper will take place. This is true, also, of such other impurities as will decompose steam at the refining temperature of copper.

Steam may be used in various ways: for example, in the same manner as air, with the same pressure, the same number and size of pipes, and the same free admission to the furnace. In this operation, some of the copper will be oxidized, but less than with air; also, the operation will be completed in less time. If, however, the admission of air is decreased as the impurities in the copper are removed, until all furnace openings are closed and a non-oxidizing atmosphere is maintained in the furnace, little, if any, of the copper will be oxidized, except such as will be oxidized by the air entering the furnace through leaks in the brickwork, around the pipes, and at other openings. This amount is sometimes sufficient to require deoxidizing.

During the tests here recorded, several charges of copper were cast into anodes directly after removing the impurities with steam. These anodes were as good as the regular product; the copper, however, was treated in a special furnace where the admission of air was under close control.

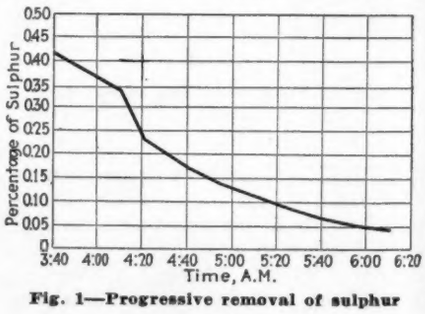


Fig. 1—Progressive removal of sulphur

The anodes were made from black copper containing 3 to 4 per cent of impurities, mainly sulphur and iron. Removal of these impurities by air when using six ¾-in. pipes and from five to six hours' flapping, consumed 500 ft. of pipe, and required 14 to 17 poles, averaging about 700 lb. each, for deoxidizing. The charge was 200 tons.

When steam was substituted for air on these furnaces the operation was conducted in the same manner as when using air. Dense poling was customary when using air, but this seemed unnecessary when using steam. Green wood contains 35 to 50 per cent of water, and the rapid generation of

steam when a pole is submerged in copper causes the violent agitation which expels the gases—mainly sulphur dioxide. The other gases given off by the poles are reducing and likely to do more harm than good. When using steam, any degree of agitation necessary to remove the sulphur dioxide can be obtained.

Steam at 50-lb. pressure was used on the first charge treated. This pressure expelled the sulphur dioxide about as fast as it was formed, and dense poling was unnecessary. The steam pressure was reduced to 15 to 20 lb. on the second charge treated, some of the sulphur dioxide remained with the copper, and dense poling could be used advantageously. The accompanying chart (Fig. 1) shows the removal of sulphur from this charge.

The best time previously made with air on this grade of material was slightly under four hours. The amount of pipe used per charge with steam was 200 to 250 ft. and from five to nine poles were required for deoxidizing. As the average copper content of the anodes was slightly higher, after changing to steam, the assumption was warranted that the removal of impurities was equally good, if not better.

The shift from air to steam can be made easily, usually a reducing valve, steam trap, and steam hose being all the additional apparatus required.

Deoxidation of Copper

In deoxidizing copper by poling, when a pole is submerged in molten copper the wood is charred, and steam, carbon monoxide, hydrocarbons, and hydrogen are given off. The steam stirs the copper and tends to disseminate the reducing gases and charcoal through the metal. The action of steam brings a large amount of the oxide into contact with the reducing gases and charcoal, thus facilitating reduction. As the effect of stirring with a pole depends upon its water content, green wood is used.

The poling operation is more efficient when the oxygen content of the copper is high and becomes rapidly less so as reduction proceeds. Efficiency also drops as the steam is expelled from the pole. Taking the average analysis of green wood as H_2O, 40 per cent; C, 30; O, 25.5; and H, 3.7 per cent, the efficiency of the poling operation is usually found to be very low.

Copper can be advantageously deoxidized by finely divided reducing material, such as charcoal and coke. The pulverized material is injected into the bath of metal by superheated steam, which is widely distributed in the molten bath and brought into intimate contact with the oxides to be reduced. By this method, less reducing agent is required and the time of deoxidizing is materially shortened.

Other gases can be used for introducing the reducing material, but steam has many advantages. It is usually available and cheap, and in addition to such advantages as the possible production of water gas in contact with the oxides to be reduced, steam tends to prevent impurities from entering copper, as well as to remove them when present.

Steam must carry sufficient superheat to prevent condensation. The pulverized reducing material is delivered into the steam line. The steam line is under pressure when the pipes are submerged in the bath, but this pressure is overcome by carrying a higher pressure on the reducing agent container. The reducing agent should be introduced at several points, the number of these depending upon the size of the furnace. The pipes can be of the same size as those used for oxidation. When steam is used for oxidation, the same header and pipes can be used for the reducing agent.

In the course of a series of tests, finely divided reducing agents were used in a 25-ton tilting furnace, fired with pulverized coal. On a bypass in the steam line, near the furnace, was located a superheater and a place to introduce the reducing agent into the line, permitting the use of the line for both oxidation and reduction. The container for the reducing agent was a filter-press blow case, from which the reducing agent was forced by air pressure. The amount of air required for this purpose is small. For large-scale operations a compressed reducing gas possesses advantages, and the cost would be slight.

Pulverized coal containing over 1 per cent sulphur was tried for deoxidizing anode copper. Black copper was melted in the small furnace previously mentioned. After removing the slag, the furnace contained about 23 tons of metal, analyzing as follows: Cu, 98.58 per cent; S, 0.23; Pb, 0.12; As, 0.125 per cent. Steam was passed into this copper through a ¾-in. pipe during 1 hour and 45 minutes, after which the analysis was: Cu, 99.10 per cent; S, 0.015; O, 0.671 per cent.

The reducing agent tank contained about 100 lb. of charcoal from a previous run. As the tank had to be taken apart to remove the charcoal, that material was passed through the copper. Steam at 20-lb. pressure was used to carry the reducing agent through a steam hose connected to 1½-in. pipe which discharged into the molten copper. The reducing agent container was under an air pressure of 30 lb.

The charcoal was passed through the copper in about five minutes. Samples taken after the treatment showed: Cu, 99.18 per cent; S, 0.0096; O, 0.410 per cent.

Two hundred twenty pounds of pulverized coal was then put into the reducing agent container, the coal being taken from the regular furnace supply. It was supposed to pass through a 200-mesh sieve and to contain approximately: water, under 2 per cent; volatile matter, 30; ash, 5; sulphur, 1.25 per cent.

The same apparatus was used with coal as with charcoal. The coal was passed through the copper in five minutes. After using the pulverized coal the sample taken showed: Cu, 99.45 per cent; S, 0.0072; O, 0.225; Pb, 0.065; As, 0.096 per cent.

As the sulphur in the copper was 0.0024 per cent lower after using the coal, no sulphur from the coal entered the copper. Since four to five times as much coal was delivered at one place in the copper as could be used economically, and the amount of steam supplied was very low for the coal, all conditions were favorable for the copper to take up sulphur.

The use of steam makes available cheap reducing agents which contain small amounts of sulphur for deoxidizing such material as anode copper. Often, too much oxygen is left in the anodes, which adds to the electrolytic refining cost. Possibly a cheap reducing agent may help to correct this condition. In the production of fine copper, the reducing agent should be pure or at least should contain nothing which might contaminate the copper.

Usually, charcoal affords a lower cost per unit of reducing power than poles. About 35 per cent of the pole is used as a brand, whereby its reducing action is small, thus making the comparison even more favorable for charcoal.

The depth at which the reducing agent is discharged in the metal is important. Sufficient depth of metal above the discharge should be provided to obtain the maximum effect of the reducing agent. When using a ¾-in. pipe, steam at 20-lb. pressure, and discharging at a depth of 13 to 15 in., the amount of pulverized charcoal which could be used advantageously was found to be from 10 to 15 lb. per minute. When the oxygen in the copper was high, 15 lb. or even more could be used with little wastage; and when the oxygen was low, wastage occurred with 10 lb. By regulating the steam to obtain the proper stirring and diffusion effect, and the amount of reducing agent to correspond to the oxygen content of the copper, good efficiency can be obtained throughout the operation.

Melting Can Also Be Improved

Though the use of steam for removing impurities, and of a pulverized reducing agent for deoxidation, eliminates some of the objections inherent in the standard method of fire refining, the subsequent melting, which imposes numerous difficulties, remains unchanged. To realize any marked increase in efficiency a change in the manner of conducting the melting operation is necessary.

Impurities in blister are usually combined with or alloyed with the copper. Those in cathodes are mostly in the form of oxides, and would pass off or enter the slag when the cathodes are melted were it not for the reducing action of the gases and the reducing agents present in the cathodes. Practi-

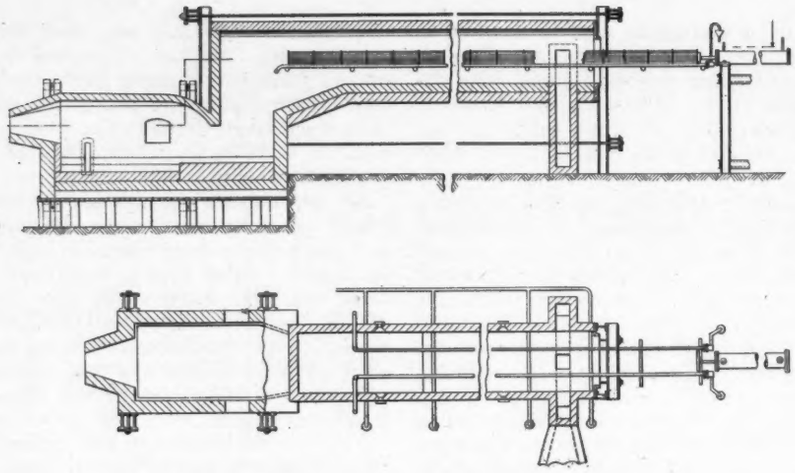


Fig. 2—Improved type of cathode-melting furnace

cally all cathodes contain sufficient reducing agents to reduce oxides when melted.

In both blister and cathode copper the impurities removable by oxidation can be treated much more effectively during the melting period than after the copper is melted.

Simultaneous Melting and Refining

In this process a reverberatory furnace with a sloping hearth is used to melt the copper. As the copper is melted on the sloping hearth, the melting can be made a continuous operation to good advantage.

The copper is subjected to the melting and refining action of hot combustion gases whose composition and nature are controlled in accordance with the nature of the impurities in the charge. Molten material is continuously drained from the charge, and the charge is always exposed to the action of the gases, making possible the removal of a maximum amount of impurities. The chemical composition or reactive quality of the gases surrounding the copper is so closely controlled that melting and refining take place simultaneously. The heating gases are maintained in chemical equilibrium with the copper, and may vary from oxidizing to reducing, according to the nature of the impurities to be removed.

When melting copper in which the impurities are uniformly distributed, if the chemical composition of the hot gases of combustion is regulated carefully in accordance with the nature of the impurities, the resultant copper will be free from all removable impurities. When melting copper in which the impurities vary, to make a finished product in one operation may be impossible, because the composition of the hot gases cannot be regulated to suit the requirements of each of the individual pieces making up the charge. If the gases are regulated to suit the average of the impurities, some impurities will remain in the copper and some of the copper will be oxidized. If the gases are regulated to suit the pieces containing the maximum impurities, considerable oxidation of copper will result and reduction will be necessary.

Some preliminary work was done, in the tests here recorded, in melting black copper. This copper was high in sulphur and iron, either of which was likely to vary in amount as much as one-half of 1 per cent. The furnace used for the melting had a hearth dimension of 8x18 ft., was oil fired, and discharged into a flue which carried the gases from several other furnaces. A melting hearth of magnesite brick was put in this furnace. This hearth was the full width of the furnace and started at the bridge wall and extended 10 ft. toward the front. It was 10 in. above the furnace bottom at the point where the metal flowed off the hearth. The hearth had a pitch of 5 in. in its length and 1 in. toward the center. The sump between the end of the melting hearth and the front end of the furnace held about 7 tons of metal. That this furnace and the material were not suitable for obtaining good results was realized, but it was believed that the information obtained would justify the trial.

In melting this copper sand was added as a flux to prevent the oxides formed from building up on the melting hearth. No difficulty was experienced in removing the oxidizable impurities, but some copper had to be oxidized to take care of the wide variation in the impurities. Though less copper was oxidized than by the usual method, considerable reduction was required.

Results obtained were very promising, and those conducting the tests decided to make some changes in the furnace and use it to melt cathodes. The furnace was placed where the cathodes could be handled with a charging crane and the metal discharged into a fine-copper furnace. Also, the melting hearth was changed from the back to the front end of the furnace. The sump into which the metal drained held about 12 tons and the space above this sump acted as the combustion chamber.

The furnace was fired with pulverized coal for a short period. An ordinary pipe burner was used. Four charges, all high in sulphur, were melted with this fuel. With a suitable burner, pulverized coal could undoubtedly be used for the purpose.

The pulverized coal was then replaced with fuel oil and melting resumed. The copper from the first charge melted contained over one-half of 1 per cent oxygen, but the oxygen content in subsequent charges decreased gradually to 0.04 per cent in the last charge. Except for the high sulphur content of the copper, usually about 0.003 per cent, a satisfactory product was made. During this run, in which about 65 tons of cathodes was melted, no slag was produced. Sufficient slag should be present to protect the metal and to take up any oxides present. In melting subsequent charges a basic slag cover of sodium silicate was used.

As the row of cathodes nearest the burners melted so much more quickly than those further back, the furnace was tapped and recharged when the first row melted. During charging the furnace cooled and the exposed copper, partly melted, in the back rows was oxidized. This and other objections of intermittent charges clearly indicated that melting should be continuous to obtain the most favorable results.

The heating furnace used in rolling copper was considered most suitable for this work. Such a furnace could be placed so that it would deliver the cathodes on the melting hearth of the present furnace. A number of changes had to be made in the heating furnace to handle cathodes and to take care of their relatively low conductivity of heat. The operation was planned so that the cathodes would take up at least 60 per cent of the heat necessary to melt them before they were discharged on the melting hearth.

The furnace was oil fired, and was operated with a balanced draft. Steam at 300-lb. pressure was used to atomize the oil. The oil and the air for combustion were delivered to the burners under constant pressure. A sample of the gas over the melting hearth was taken and passed through a recording carbon-dioxide meter. The combustion conditions could be very closely controlled, thanks to the assistance of Mr. C. H. Smoot, of the Smoot Engineering Corporation.

The furnace was changed where the heating furnace joined it. Its melting hearth was made smaller and the furnace roof changed so that it would concentrate the heat at the point where the charge was delivered on this hearth.

An electric-driven ram or pusher was used for passing the cathodes through the furnace and delivering them on the melting hearth. The cathodes in passing through the furnace rested upon two 2½-in. water-cooled pipes, which extended the length of the heating furnace, ending above the melting hearth. The cathodes were delivered to the furnace on trucks, from which an electric hoist

picked up a pile of the size desired and placed it in front of the pusher and on the pipes which support the cathodes when passing through the furnace. When this pile of cathodes was pushed into the furnace, each pile was correspondingly advanced, and if the furnace was full the pile at the discharge end of the pipes was dropped to the melting hearth. The melting hearth held about 5 tons of cathodes.

Some time was spent in trying out the furnace and equipment. During this period 50 to 60 tons of cathodes was melted. Changes which this work indicated to be advisable were made in the furnace and equipment.

The heating furnace was planned to handle piles of cathodes between 22 and 24 in. high. A pile this high was not properly heated when it reached the melting hearth. Though the top cathode might be melted and the edges of the pile show considerable melting, the copper a few inches from the exposed surfaces would be of a low temperature. The piles were reduced in height to about one-half, which did not greatly help matters, since, with the additional space between the pile and the furnace roof which this change gave, less heat traveled along the sides and bottom of the piles. Heat distribution was not good to start with, and it became worse after these changes were made. The furnace roof should have been lowered, or, preferably, the pipes upon which the cathodes were pushed through the heating furnace should have been raised sufficiently to get an even distribution of the heat around the piles of cathodes. Financial reasons made advisable the collection of all information possible before making costly changes.

A test was made on the furnace to determine how closely the melting conditions could be maintained as measured by the oxygen content of the resulting copper. After melting several charges to get the gas conditions regulated, the furnace was run for twelve hours in which no change was made in the oil, air, or draft conditions. During this period about 60 tons of cathodes was melted and the furnace was tapped five times. A sample taken of each tap showed:

No.	Per Cent Oxygen
1	0.385
2	0.400
3	0.400
4	0.385
5	0.400

The small difference in the oxygen content of the copper from the different taps showed that the composition of the gases varied little, if any, during the run. On the next charge the oxygen content of the gases was slightly reduced. The product showed: O, 0.35 per cent; S, 0.0004. The effect on the sulphur content of the copper, of melting cathodes in the bath of metal, is shown by the analysis of a charge about 40 per cent of which was melted on the melting hearth, and the remainder pushed across the melting hearth into the bath of metal and melted. This metal showed: O, 0.070 per cent; S, 0.013. During the melting the composition of the gases was such that the product from the melting hearth should have contained oxygen about 0.10 per cent; sulphur, 0.0012 per cent.

In this connection the copper from a subsequent charge appeared to be higher in sulphur than the conditions warranted. On the following charge the composition of the melting gases was changed to strongly oxidizing. Analysis of these charges showed:

First Charge Per Cent	Second Charge Per Cent
O 0.120	0.357
S 0.0025	0.0023

The high sulphur was partly the result of not having a slag cover on the molten metal of these two charges. The slag was allowed to flow off with the metal from the previous charge and no slag-forming material was added to replace it. An examination of the cathodes showed the presence of calcium sulphate, undoubtedly the source of the sulphur in the product. No other sulphate was found on the cathodes, which could not be decomposed considerably below the melting temperature of copper. With the method of melting used, no sulphur derived from a sulphate which is decomposed at a temperature much below the melting point of copper would be in the product. It is much cheaper to remove the impurities by washing the cathodes than it is to remove them from the copper after melting. Though the slag cover used will take care of limited amounts of impurities, it is not a substitute for washing the cathodes. Some of the succeeding charges melted showed as follows:

No.	Per Cent Oxygen	Per Cent Sulphur
18	0.160	0.001
20	0.145	0.0013
22	0.101	0.0012

Mechanically the furnace became difficult to operate for more than two charges, without allowing it to cool. In cooling and heating the furnace, the copper near the melting hearth was oxidized and the two charges just about took care of the cathodes containing some oxidized copper. The furnace was discontinued, as it had been run a sufficient length of time to show its defects and to indicate the changes necessary to make it a satisfactory continuous furnace. The drawing showing the heating furnace (Fig. 2) embodies the changes found necessary or advisable for operating the furnace. That the oxygen content of the copper melted in this furnace was high, 0.10 per cent being the lowest figure obtained, was entirely caused by mechanical difficulties which can be overcome easily.

The twelve-hour run on this furnace, in which the oxygen content of the copper varied only 0.015 per cent, shows how closely the composition of the gases can be controlled. Whether the gases be oxidizing or reducing, or any degree of either, the products are evidently uniform so long as their composition is unchanged. With close control of combustion any composition of the gases desired can be obtained and maintained, and the product obtained by this method must be in accordance with the composition of the gases.

The work showed the desirability of transferring the molten copper to a holding furnace for casting. Casting requires much less time than melting, and a holding furnace for handling a relatively large tonnage of metal is small and inexpensive. A holding furnace also gives an opportunity to correct any irregularities in the product, caused by varying composition of the material melted, or by faulty control of the combustion conditions.

A molten cover for the copper, instead of the usual charcoal or coke cover, can be used advantageously in this furnace, soda glasses fulfilling the requirements. As these glasses range from basic to acid, a cover for any kind of furnace lining is available. Calcium oxide or calcium fluoride may be added to change melting point and fluidity of the glasses. These glasses or slags provide an effective protecting cover and serve to maintain a uniform quality of copper during casting.

Laboratory experiments to produce oxygen-free copper were completed, but this work was not tried on a commercial scale, because an additional operation was required and the cost would be increased accordingly. The object of the investigation was to produce equally as good a product as by the present method of fire refining, at a reduction in cost, or to produce a better product at the same cost. Moreover, the demand for any considerable tonnage of oxygen-free copper appears to be uncertain.

The investigation shows the possibility of improving the present method of fire refining copper. Use of steam instead of air for removing impurities from copper has well-defined advantages. Steam requires less time, costs less, reduces the amount of poling required, and offers, under special conditions, the possibility of eliminating poling.

Finely divided reducing material and steam have certain advantages over poles for deoxidizing copper. High efficiency can be obtained throughout the deoxidizing period, impurities are prevented from entering the copper, and reducing agents containing only a small amount of such impurities as sulphur, can be used for deoxidizing anode copper. The deoxidation is rapid and the cost is low. Some of the advantages of melting and refining simultaneously are: Low initial cost of equipment, lower slag production, few repairs, low operating cost, and a better product.

Dilution—Another Depletion Problem

W. Earl Greenough

President, Atlas Mining Company, Mullan, Idaho

THE present income tax law imposes upon the taxpayer, and the government alike, the necessity of attempting to do something that cannot be done—namely, to forecast and assign to every mineral deposit its precise and full value, as well as the number of years of life its operation will attain. This comprehends forecasting the value per unit and the number of units. Since every mineral deposit by its very nature renders impossible, prior to its exhaustion, a measure of its true value, it naturally follows that any value assigned prior to this date is sure to be inaccurate. But the regulations require it must be done, and accordingly for each mine a value was assigned as of the basic date of March 1, 1913. Despite every effort that may have been taken to make them accurate, the values thus assigned have in nearly every instance been incorrect.

Where later operations have disclosed that the assigned value was materially disproportionate to the true value, through the presence of a different number of units from what had been assumed, the Revenue Bureau has sought a method of correction. The solution it has adopted is to retain the initial erroneous assigned value and make a redistribution of this value to the corrected number of units. Spreading the value to a larger number of units is called "dilution"; redistributing the value to a smaller number of units is "augmentation."

Undervaluation of mineral deposits by the Bureau has been more frequent than overvaluation, since the Bureau comes in contact mostly with the profit-making mines, and these are thus a select, better-than-average group, with better-than-average chance of strong, persistent mineralization. Therefore, dilution is more common than augmentation.

The regulations state that the initial estimate of total units, but not of total value, "may be revised with the approval of the commissioner." Plainly, this approval may as well be given to a request from members of the Bureau as to a request from a taxpayer.

To see what consequences follow from dilution, let us assume a property estimated as of March 1, 1913, to contain 100,000,000 units of ore. This 100,000,000 units, the Bureau holds, is the owners' capital, and the whole of his capital, and asserts that he may have the money value of this capital returned to him tax free. A valuation is assigned to these units which, we may assume, works out to be $2,000,000, or 2c. per unit. Obviously, then, the depletion rate per unit is 2c.

Abstract from testimony before the Joint Committee on Internal-Revenue Taxation, Dec. 12, 1930.

After some years, say half the original units have been mined out, with 50,000,000 units thus remaining at 2c. each or a "value remaining for depletion" of $1,000,000. The owners' development of the deposit now discloses an additional quantity of ore, amounting to another 50,000,000 units. He applies for discovery value on this additional ore, but is denied such value by the restrictions placed on the discovery clause by the regulations. The Bureau thus holds consistently to its view, that what was estimable on March 1, 1913, was his capital and that whatever may later come to light is not capital.

But now a complication arises as to how to compute the annual depletion. Here are two lots of 50,000,000 units each; the original lot is admitted by the Bureau to have a value of 2c. per unit, while the new lot is denied any value. Complications obviously arise, through inability of the Bureau to check how much of the year's production comes from the one lot and how much from the other; for obviously, if all the year's output came from the original units, a substantial depletion will be deductible, but if all comes from the new units there will be no depletion, and if production comes partly from each lot, there will be an intermediate amount of depletion.

Faced with this quandary, we may assume that the Bureau requests and receives approval of the Commissioner for reapportionment. The $1,000,000 balance of the original valuation is retained and is spread, or "diluted," to cover the 100,000,000 total units, giving a new depletion rate of 1c. per unit. Now all the difficulties seem solved, for now all units carry the same value and the Bureau need not be concerned whether the yearly output is extracted from the original lot, the new lot, or from both. But are the difficulties solved? The Bureau insisted that only the units estimable in 1913 constitute capital, and thus possess a money value. But just now, by dilution, it has placed a 1c. value on units not estimable in 1913. This can only mean that these new units have value as capital. Thus the Bureau is inconsistent and violates its own tenet about limitation of capital to ores estimable on the basic date.

This is not all. Having admitted that the original units, as capital, have a proper and intrinsic value of 2c. each, the Bureau, by dilution, arbitrarily withdraws from these original units half their value, reducing them to a value of 1c. each. And with the money so taken from the original units it is possible to give a 1c. value to the new units. This is worse than inconsistency.

Even this is not all. The Bureau prescribes that revaluation is prohibited save in cases of fraud, gross error as to facts determinable on the basic date, and so forth, and then only with the Commissioner's approval. But without the Commissioner's approval of revaluation, and on none of the grounds held to justify revaluation, the Bureau has arbitrarily reduced the value of 50,000,000 original units from 2c. to 1c. each. This is certainly nothing if it is not revaluation. To claim that this is not a revaluation "of the property" would sound very much like quibbling.

Suppose, to avoid these several predicaments, the Bureau adopts the view that it will grant the 2c. value on production from either lot indiscriminately. To do this it must in spirit take away the 2c. value from some of the original units; thus, it revalues those units. It also allows depletion to the new units, although they were never valued; and thus again violates its proposition that ores developed after the basic date are not capital.

Finally, if the Bureau has a watchman in the mine to check how much ore comes from the original units (or if it trusts the taxpayer's word as to this) and allows the 2c. depletion only on this part of the production, then it is placed in the anomalous and wholly false position of insisting that some units present in a mine are capital and other identical units are not capital, but only potential income. The utter fallacy of this position is clearly apparent.

Thus it would appear that no matter in which direction the Bureau may turn, it runs into inconsistency, violation of its own rules, and sound economics, or even, in taking value from units already valued, infringement upon the security of the established value of the unit of depletion.

All the difficulties mentioned flow from an unsound premises—namely, the view that only such units in a property are capital, as can be arbitrarily estimated on a chance date. The consequence of this unsound view is eventual hardship on the taxpayer. Determination of depletion by the percentage method will automatically avoid all these troubles and bring about just consideration to both parties.

New Publications

APPLIED GEOPHYSICS. *By A. S. Eve and D. A. Keyes, London: Cambridge University Press. New York: Macmillan & Company. Price, 12s. 6d., or $4.50.*

THE authors of this volume are professors of physics at McGill University, in Montreal, and so they speak with authority of the physical side of the new art of applied geophysics. They have produced an excellent work, which has been needed for some time, destined to serve as an introduction to the mathematical and physical intricacies of the science of geophysics. The book is not a textbook, nor an exhaustive treatise, yet it deals sufficiently with the underlying verities, the formulas and theories, to provide a safe jumping-off place for those who would go on into the more specialized and complete papers on the various branches of geophysics.

The book opens with an introductory chapter which treats in an interesting manner of the relation of pure to applied geophysics, and of charlatans and divining rods to the scientist. Some history is given of magnetic methods, and of the age-old divining rod, which yet retains its youthful vigor.

Magnetic methods of prospecting, being the oldest, are naturally treated first. Also, they bear the merit of being the most familiar. Instruments are described, their theory is dealt with, the mathematics briefly discussed, field operations are outlined, and examples of actual surveys cited.

The section on electrical methods is divided into two chapters, the second of which is devoted to electromagnetic techniques. In the first are considered the various potential methods as developed by Schlumberger, Lundberg, Gish and Rooney, Weaver, the so-called "leap-frog" technique developed by the authors themselves, and the little-known "megger" method. The latter is of interest since it presents a possibility of reducing the cost of exploration through the use of this instrument by mining companies themselves. A good part of the material comprised in this chapter is derived from the work carried out by the authors in conjunction with the U. S. Bureau of Mines, some of which has appeared in the bulletins of that organization.

The chapter on Electromagnetic Methods opens with a short, general theoretical discussion, and then proceeds to take up the methods under two classifications, horizontal loop methods and vertical loop methods. In each subdivision several techniques are described, including the well-known ones of Lundberg and Sundberg; Radiore; Mason, Slichter and Hay, among others.

The chapters on Gravitational Methods and the Torsion Balance, Seismic Methods, Radioactive and Other Methods, follow the same plan of outlining the theories of operation, describing the instruments, suggesting field procedures, and illustrating all with actual examples. An appendix goes deeper into some of the mathematical development, for those who desire to follow it up.

The statement on p. 56 that Fox, in 1830, "worked inside a Cornish tin mine and discovered copper sulphate deposits," is evidently a misprint for copper *sulphide*. A far more serious error occurs on p. 21, where the authors say "Often magnetite is found disseminated through other minerals, such as rock-salt deposits, and this fact is made use of in searching for such salt domes." Salt domes are discovered by means of magnetic measurements, but owing to their *diamagnetism*, they contain no magnetite. This illustrates the necessity of sound geological knowledge in the application of geophysics.

Such slips do not mar the general value of the book, which is one to be highly recommended to any desiring an easily readable introduction to the science of geophysics. SHERWIN F. KELLY.

■ ■

THE WORLD'S ECONOMIC DILEMMA. *By E. M. Patterson. New York: Whittlesey House, McGraw-Hill Book Company. $3.50 or 14 shillings.*

"A WORLD whose economic life is highly interdependent and whose economic welfare can be advanced only by close cooperation, but a world whose economic life is almost of necessity organized along national lines, an organization which to a degree helps in each country to stabilize the local economy but often does it in a way that injures other countries and reacts directly or indirectly against itself." These are the reasons given by the author for the world's economic dilemma.

The main part of the book is devoted to an objective presentation of the facts responsible for the present situation, such as increasing population with attending pressure; natural, climatic, and geographical conditions influencing movements in population; large-scale production; the gold standard; market conditions; corporate growth and investments; and economic activities of governments. The author then discusses the present position of the leading industrial nations, showing Great Britain's rise and present decline, Germany's economic recovery, the strong position of France, the growing difficulties in Italy and Japan, and as a climax the dominating influence of the United States.

This presentation is mainly a statement of facts, and the author does not often allow prejudices and personal opinion to color the review. He hints at an increasing activity and supervision by governments in economic affairs, not necessarily from choice, but as a natural consequence of events; he does not, however, go far enough, and he almost entirely ignores the developments that are taking place in Russia. He takes a stronger stand in his discussion of Italy, stating that its present protectionistic policy cannot solve the problems of a country so densely populated and with so few natural resources. In a discussion of the different methods used to stabilize the national currencies during the post-war period he apparently favors the French method rather than the British one.

As a solution of the dilemma he makes four suggestions, none of which is said to possess originality, and which he admits will not bring immediate and full relief. His statement that evolution must be gradual—in economic life as well as in nature—shows the conservatism that characterizes the entire presentation. The first point in his recommendation is the use of commercial treaties and reduction in tariffs by mutual concessions and the application of most-favored-nation clauses. Second, he advises international cooperation through cartels and trusts, and international agreements between banks. Third is his plea for the International Chamber of Commerce, a post-war creation; and finally he argues in favor of the League of Nations.

The author does not pretend to go beyond a presentation of fundamental facts, in the hope of stimulating an interest for the subject, that may lead to more detailed study. In this he has succeeded. His presentation is clear and the book is well written.

B. H. STROM.

■ ■

GEOLOGY OF THE GOLDEN AREA, COLORADO. *By J. Harlan Johnson. Colorado School of Mines, Quarterly, July, 1930.*

This issue of the *Quarterly* is devoted to the second edition of a paper by Professor Johnson, which appeared first in 1925. In preparing for the new edition, the opportunity was taken to correct errors, to add newly discovered information, and to enlarge the scope of the article in certain directions in the hope of making it more useful. Primarily, the bulletin is intended for students at the school in connection with their field trips, but the information may also be used by others.

Personal Notes . . . Comment . . . Criticism

R. D. Leisk has been appointed assistant general manager of the United Verde Extension Mining Company.

J. C. Ingersoll, geologist, is in charge of the operations of Arrowhead Gold Mining at Yucca Grove, San Bernardino County, Calif.

S. Smith Meyer, mining engineer, of Evje, Norway, arrived in New York on Feb. 18. He plans spending two months in studying flotation practice in the United States and Canada.

J. B. Knaebel has joined the staff of the U. S. Bureau of Mines, with headquarters in Washington, D. C. He will work on the mining methods investigations being conducted by the Bureau.

J. W. Littleford, formerly engaged in phosphate flotation work with the International Agricultural Corporation in Florida, is now mill superintendent of Roan Antelope Copper Mines, Ltd., Luanshya, Northern Rhodesia.

Thomas R. Akin, president of the Laclede Steel Company, St. Louis, Mo., has been elected president of the Mancha Storage Battery Locomotive Company, St. Louis, Mo., succeeding Raymond Mancha, who died on Jan. 3, 1931.

H. St. J. Somerset, general manager of the Electrolytic Zinc Company of Australasia, has been elected president of the Australasian Institute of Mining and Metallurgy for 1931. He succeeds **W. E. Wainwright,** general manager of Broken Hill South.

Frank J. Smith, of Crystal Falls, Mich., general superintendent for Oglebay, Norton & Company on the Menominee iron range, has been appointed a member of the board of control of the Michigan College of Mining and Technology, at Houghton. He is a graduate of the college, class of 1908.

Peter L. Schaefer, of the Phelps Dodge staff at Bisbee, Ariz., left New York at the end of February en route to London and Cape Town, accompanied by his wife and six-month old son. He has signed a three-year contract as assistant superintendent of the mill of the Roan Antelope Copper Mines, Ltd., Luanshya, Northern Rhodesia.

Cyril W. Knight, of Toronto, Ont., writes to correct statements in the Annual Review issue, in Mr. Paul M. Tyler's article on "Minor Metals," regarding the recently discovered deposit of radium ore (pitchblende) at Great Bear Lake, in the Northwest Territories, Canada. The deposit in question was discovered by Gilbert LaBine, a Canadian prospector, not by Shirley R. Cragg, as stated. A correct description of the occurrence of the orebodies will be found in an article, by Mr. Knight, in *Canadian Mining Journal* of Oct. 10, 1930.

Edwin C. Eckel, who contributed the article on iron that appeared in the Annual Review Number of *Engineering and Mining Journal,* is the author of "The Iron and Steel Industry of the South," published in the January, 1931, issue of *The Annals* of the American Academy of Political and Social Science. In this paper Mr. Eckel states, in conclusion: "In future periods of normal business, after the present severe crisis shall have passed, it seems probable that the South, and particularly Alabama, will show increases in iron and steel output at rates higher than those of the sections dependent on Lake or imported ores. The gradual growth of Southern markets for semi-finished and finished products will be one of the factors in such a shift in relative status."

The Mineralogical Society of America is compiling a list of the more important mineral collections in the United States and Canada, the intention being to publish the information in *American Mineralogist.* The task of collecting information on small private collections is formidable. Accordingly, the Society asks all who own either general or specialized collections to send their names and addresses, together with a brief note on the nature of their material, to Samuel G. Gordon, Philadelphia Academy of Natural Sciences, Logan Square, Philadelphia, Pa. If the collection is rich in minerals of a particular mine, locality, or district, this should be mentioned, as should also the inclusion of any specialized types, such as gems, meteorites, or other notable rarities. The society also seeks information regarding other collections which correspondents consider should be included in the directory. Details relating to collections consisting wholly of the minerals and ores of an individual mine, and on permanent exhibit at the mine office, will also be welcomed. The names and addresses of small local dealers specializing in the minerals of particular localities will also be of interest.

N. F. Parkinson, secretary-treasurer of the Falconbridge Nickel Mines Company, writes from Toronto in comment of Mr. Thomas W. Gibson's article on nickel in the Annual Review Number, which would seem to indicate that the total production of nickel in Canada for the nine months ended Sept. 30, 1930, was from the mines of the International Nickel Company and that all the matte produced was treated at its refinery in Canada, the old Mond refinery in Wales, or at the plants at Huntington, West Virginia. Mr. Parkinson adds: "I have checked the figures as to total production for the nine months with the Department of Mines here, and am satisfied that these figures cover the total production of nickel in Canada, including the Falconbridge production. Falconbridge Nickel commenced production in Canada in February, 1930. Matte was shipped to our refinery, Falconbridge Nikkelverk, at Kristianssand, S. Norway, and our nickel was produced as refined nickel commencing in October, 1930. The proportion of the production applying to Falconbridge for these nine months ended with September, 1930, is as follows: Quantity of ore smelted, 62,419 short tons; matte produced, 2,283 short tons; nickel content of matte produced, 2,625,891 lb.; copper content of matte produced, 1,143,250 lb.; matte exported to Norway for refining, 2,198 tons."

Byproduct Silver

To the Editor of "E.&M.J.":

Statements in H. M. Bratter's article, "Silver," 1931 Annual Review Number, relative to the byproduct nature of silver production, seem to overemphasize this factor. He states in the opening paragraph: "As the major part of the silver produced is a byproduct of copper and zinc. . . ." As a matter of fact, argentiferous lead ores are the principal source of byproduct silver. Ores more valuable for lead than any other metal produce 24 per cent of the world's silver; copper ores, 14 per cent of the world's silver; and zinc ores, 7 per cent of the world's silver.

In the closing paragraph he states that "in normal times, no less than four fifths of the silver output is a byproduct in the recovery of other metals." This is true only of the silver production of the United States, but not of world production, as apparently implied. A study of this particular phase of silver production was recently published by the Bureau of Mines as "Economic Paper 10." The paper presents the fact that ores in which silver is the principal source of revenue accounted for 48 per cent of the world's silver production.

CHARLES W. MERRILL

Washington, D. C.

OBITUARY

William J. Pearce, pioneer California and Nevada mining man, died in San Francisco on Feb. 25. He was 81 years of age.

George Erskin Ewing, mine manager and backer, was killed on Feb. 12, by falling rock at the Douglass mine, near Mina, Nev., of which mine he was part owner.

Hubert Edwards, a resident of Montana since 1870, died in February near Butte. He had served as chemist and assayer for many mines and assay offices during his long residence in the district.

John McColl, Colorado pioneer and mining man, died on Feb. 10 at his home in Denver after a short illness. He was 73 years of age, and lived in Leadville from 1880 until about 1900, operating various properties in that then booming district.

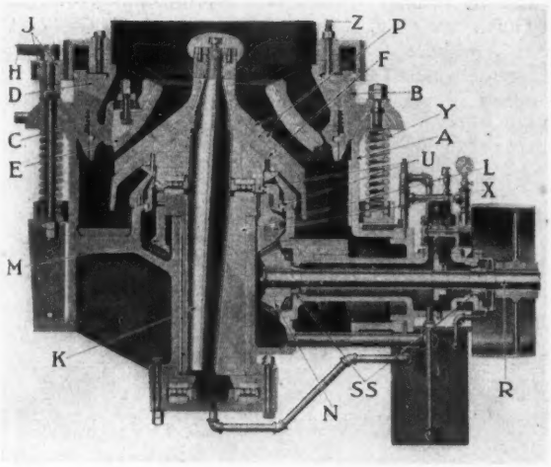
Dr. Robert Stewart, geologist and medical practitioner, died on Feb. 24, in the Toronto General Hospital. He had been in the employ of the Hudson Bay Company and the Ontario Bureau of Mines during most of his career, and was considered an authority on the Hudson Bay district.

Patrick J. Donnelly, former superintendent for the C. E. Loose interests in the Tintic district of Utah, died at his home on Feb. 9 of pneumonia. Mr. Donnelly, who was born in Ireland in 1859, had been a resident of Eureka, Utah, for 47 years. He is survived by his widow and four children.

INDUSTRIAL PROGRESS

This Cone Crusher's Head Supported on Eccentric

Other Equipment



Sectional view of new cone crusher. Head is supported on the eccentric. See text

A NEW cone crusher—the Telsmith—has been announced by the Smith Engineering Works, Milwaukee, Wis. It may be had in three sizes—Nos. 24, 36, and 48. No. 24 has a 3-in. feed opening, requires 25 to 30 hp., and has a capacity ranging, according to size of product, from 15 to 20 tons, ⅜-in. discharge, to 50 to 60 tons, 1¼-in. discharge. No. 36 has a 4½-in. feed opening, takes 50 to 60 hp., and has a capacity ranging from 35 to 45 tons, ½-in. discharge, to 110 to 130 tons, 1½-in. discharge. No. 48 has a 7-in. feed opening, takes 75 to 100 hp. and will crush from 50 to 65 tons, ½-in. discharge, to 170 to 210 tons, 1½-in. discharge.

In the cone crusher, the conical head gyrates so rapidly that every piece of rock is pinched several times while passing through, very little oversize being discharged. A sectional view of the new machine is shown herewith.

The crusher has an umbrella-shaped head, *PF*, fixed upon a gyratory shaft *K*, without upper support or support or suspension bearing. Its frame is of steel, in two sections, the lower part, *A*, supporting the eccentric *L*, and the upper part, *B*, carrying an adjustable concave member, *CDE*. The new cone crusher differs from other crushers of this type in that the head is supported on the eccentric, *L*. In this machine the concave crushing member, *E*, is fastened by bolts in a conical bowl, *C*, zinc being poured between the concave liner and the bowl, so as to prevent movement between these parts. The discharge opening is altered by adjusting the concave bowl, *C*, in the upper frame, *B*, by means of the adjusting gears, *J*, and the segmental threaded ring, *D*. The upper main frame, *B*, is supported upon the lower section, *A*, by means of curved flanges, to allow tilting of the upper frame. Heavy springs, *Y*, are provided to hold the upper frame in a normally fixed position, snug against the lower frame; but, when choked by over-feeding or tramp iron, these springs will yield, allowing the upper frame to rise momentarily at the point of stress, until the undue pressure is relieved.

A countershaft, *R*, drives the eccentric, *L*, through cut steel gears *MN*. The main drive gear, *M*, is keyed to the eccentric; and the gear is counterweighted to prevent excessive vibration. Pinion *N* is fastened to the countershaft by a key and an end-thrust plate. The countershaft unit is removable without dismantling the crusher, the countershaft being provided with anti-friction bearings, *SS*, and a sight-feed oiler.

The head mantle is of manganese steel, the shaft of hammered alloy steel, and upper and lower frames are of annealed cast steel. All bearings are force-feed lubricated.

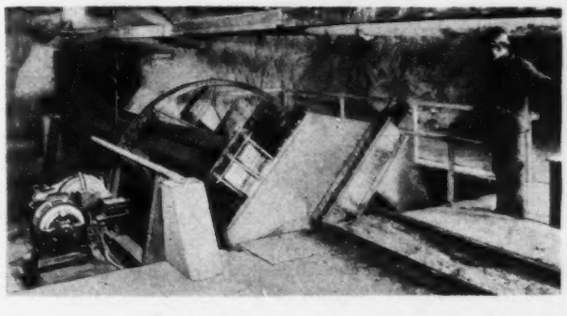
Shaft-Type Car-Dumper

Roberts & Schaefer Company, Chicago, have developed the so-called shaft-type car-dumper, shown in the cut, for use where mine cars are uncoupled before dumping. This consists of a cage body, mounted on a heavy shaft which runs full length and is set in heavy bearings at the ends. The dumper is operated by an electric motor through a speed reducer and a rope drum. The rope is passed around a ring channel at the center of the dumper and is so arranged that the dumper is overturned and returned by power. On its return, it is stopped by spring buffers. Push-button control is used. The dumper may be stopped at any point during rotation or may be reversed from any point, or can be reversed halfway and then rotated forward.

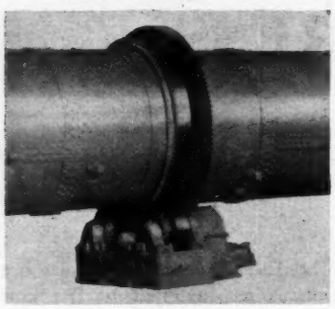
Rotary Dryers Timken-Equipped

THE Struthers-Wells Company, Warren, Pa., has announced a new line of Timken-equipped rotary dryers and kilns, including all sizes from 2 ft. 6 in. diameter to 10 ft. diameter, and lengths from 20 ft. to 200 ft. or more, as conditions demand. A recent installation included one 7-ft. diameter by 40-ft. brick-lined kiln and five kilns 7x60 ft., of the same character, for service in two plants of one large company. The complete weight of the shell, including lining and load, of the 60-ft. size is 159,000 lb.

These units are said to be suitable for



Shaft-type car dumper for uncoupled cars

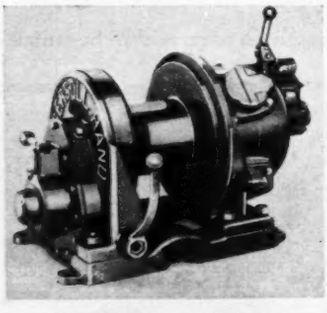


This rotary kiln has anti-friction bearings

use in crushed-stone and gravel plants, or any industrial plant requiring drying and the calcining of granular material in bulk. They may be supplied for pulverized coal, gas, or oil firing. Construction is simple. The shell consists of heavy plate sections riveted or welded and substantially butt-strapped to prevent warping or distortion under load or changes in temperature. The kilns are equipped with a refractory lining, and frequently a shell is provided with both a lined and an unlined section, so that a drying and a calcining operation can be performed in the same shell. The weight of the shell is carried on two tires or riding rings of rolled steel. Kilns of the 40-ft. size are driven at a maximum speed of 4 r.p.m. by 14-hp. variable-speed, wound-rotor, induction motors, through a Timken-equipped Farrel-Sykes herringbone-gear reduction unit. The normal speed is about 2 r.p.m. One kiln showed a demand of only 3 hp. at 2 r.p.m., owing to the thorough anti-frictionizing of all rotating parts.

General Utility Air Hoist

Ingersoll-Rand Company, New York, has added a larger and more powerful air hoist (Type HU) to its line. This has a rated capacity of 2,000 lb. at 120 ft. per minute, but will handle larger loads safely. It will take 550 ft. of $\frac{3}{8}$-in. rope. It may be used for skidding and hoisting timbers, handling tools and supplies, hauling and spotting cars, single-cable slushing, and similar purposes. It has a reversible, four-cylinder, radial-piston-type air motor, anti-friction bearings, and a jaw-type clutch. It weighs 490 lb.

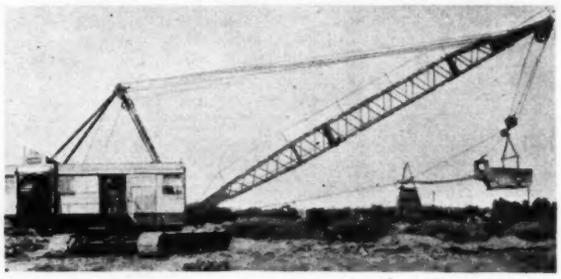


General utility air hoist of 2,000 lb. rated capacity at 120 ft. per minute

Power Shovel for Soft Ground

A new 3-yd. Diesel dragline (Class 111), introduced by the Bucyrus-Erie Company, South Milwaukee, Wis., is said to possess great mobility, by reason of its crawler mounting, and to be able to work safely in soft ground because of its large ground-bearing area. It is built for use only as a dragline and has features permitting large output. It can be knocked down for shipment in four units, each within railroad clearances. The power unit is a six-cylinder, full Diesel engine, economical in fuel, and developing high torque, even at slow speeds. This shovel is controlled completely by air, is steered from the operator's position, and can be swung and propelled at the same time.

The same builder has introduced a $1\frac{1}{2}$-$1\frac{3}{4}$-yd. shovel-dragline - crane - clamshell (Model 43-B), with either Diesel, gasoline, or electric power.



Three-yard Diesel dragline mounted for work in soft ground

Machine Shifts and Maintains Track

The Manganiferous Iron Company, St. Paul, Minn., announces that its Butler Airway Trackmaster, a combined track-shifting, raising, and general-maintenance machine, has been tested for two years on the Minnesota iron ranges in open-pit mines and that the Baldwin-Southwark Corporation, a subsidiary of the Baldwin Locomotive Works, has taken over the manufacturing and sale of it. Combined in this machine are said to be all of the properties of an air compressor, a track jack, a gang car, and a light switching engine. It weighs $7\frac{1}{2}$ tons and has a lifting capacity of 24 tons on each cylinder, or 48 tons' straight lift when both cylinders are used. It has the tractive pull of a 7-ton locomotive; also, four speeds forward and reverse, and a maximum speed of 25 miles per hour.

Some Mine-Hoist Drives

A 350-hp. motor has been supplied by Westinghouse to the Lehigh Valley Coal Company for operating an underground hoist for moving coal on a slope from one level to another. The motor is a standard-wound-rotor, Type CW, 3-phase, 60-cycle 2,300-volt, open-frame, horizontal unit, and is designed to permit control of the motor speed, and, when lowering the load, to allow the load to overhaul the motor and give regeneration for most of the distance while the motor is on the last-point lowering position. Then, to stop the hoist, the controller is notched toward the off position, giving a heavy-plugging operation.

A 500-hp. wound-rotor, Type-CW hoist motor has likewise been sold by Westinghouse to the Southern Coal & Coke Company, for hoisting on a 27-deg. slope, the loaded cars being lowered and the empties hoisted. Hoist drums are double-cylindrical and will be operated in balance. The fact that the load will be lowered, however, will give unbalanced load, so that hoist will be driven above synchronous speed and used for a large part of the operating cycle as a brake by regenerating power.

The same manufacturer will also supply motor and control equipment for the main skip hoist, No. 4 Frood shaft, International Nickel Company of Canada. Initial hoisting distance will be 2,600 ft., load 8.25 tons per trip, skip weight 5.6 tons, and hoisting speed, 2,000 ft. per minute. The hoist will be operated in balance normally. The motor will be a 2,400-hp., 40 deg. C., 650-volt, 51.5 r.p.m., separately excited, compensated d-c. machine. Control equipment will be of full-magnetic type, having automatic current-limit acceleration and retardation.

Increased Power for Mercury Arc Rectifiers

The current-carrying capacity of mercury-arc rectifiers can be greatly increased, according to statements made by Dr. A. W. Hull and H. D. Brown in a paper presented at the midwinter convention of American Insitute of Electrical Engineers. The secret of obtaining the increased capacity lies in the use of a large number of small anodes, or their equivalent, and narrow arc paths, instead of one large anode in the rectifier. This is accomplished by combining the small anodes into a single large anode and subdividing the area below it into a multiplicity of small, parallel paths.

According to laboratory investigations, the current-carrying capacity is proportional to the total cross-section of the anode arm. Without subdivision, an upper limit is imposed upon the current carried, regardless of the increase in the size of the anode.

The maximum current-carrying capaciy today is that of the 24-anode,

10,000-amp., 625-volt General Electric rectifier built for an electrolytic plant. A twelve-anode rectifier now being built will handle 14,400 amp. at 625 volts for one minute. These rectifiers have subdivided anode arms.

Portable Loader Improved

Following the introduction in 1930 of a crawler bucket-loader, having an improved helical ribbon-type feeder with a cast-steel spiral which digs, lifts, and conveys the material to the buckets, the Link-Belt Company, Chicago, has brought out a 1931 model. This is powered with either a 30-hp. Buda gasoline engine, or a 20-hp. electric motor. It can handle 1¾ cu.yd. per minute and move at 30 or 66 ft. per minute, forward, or 27 ft. per minute in reverse.

A Versatile 1-Yd. Excavator

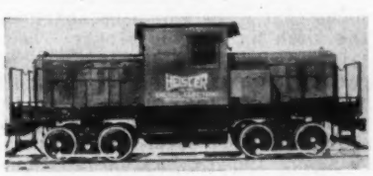
A 1-yd. revolving power shovel, called a "One-Yard Whirler," and offering, in addition to the advantages of a shovel, those of bank scoop, crane, dragline, clamshell, skimmer, and pull-scoop buckets, has been introduced by the Keystone Driller Company, Beaver Falls, Pa. It has been designed to give maximum efficiency with the skimmer and pull-scoop. It weighs 28 tons, has a tail swing of 8 ft. 6 in., and is powered with an 82-hp. Climax engine.

New Type Synchronous Motor

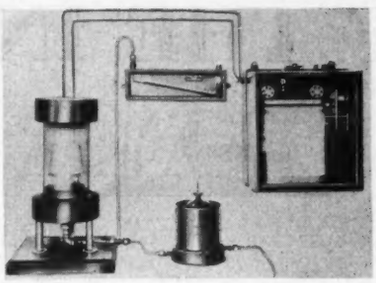
A 1,250-hp. Simplex synchronous motor and a magnetic control have recently been sold by Westinghouse to the Marquette Cement Company. This motor is a new product in synchronous motors developed for applications requiring high torque and low starting inrush. Starting performance is similar to that obtained on wound-rotor induction motors. After the motor is synchronized, it operates as a standard, salient-pole synchronous motor with the inherent high efficiency of this type.

Another Diesel Locomotive

A 6-ton Diesel locomotive has been built by Vulcan Iron Works, Wilkes-Barre, Pa., for operating in a Southern oilfield on a 24-in.-gage Decauville track, having 25-lb. rails, 3-per cent grade and sharp curves. It is powered with a 48-hp. (1,200 r.p.m.) Cummins Diesel engine, and develops a starting tractive pull of 3,000 lb. An efficient worm-gear driving and reversing arrangement is used. The cab is of the canopy type as required in hot climates.



Sixty-ton Diesel-electric locomotive develops high power at switching speeds



Flame analyzer and other apparatus for measuring heating effect of gases

Measuring Heating Effect of Gases

A useful instrument for checking the heating effect of fuel gas has been developed by the Brown Instrument Company, Philadelphia, according to A. E. Krogh, development engineer. It is called the Brown flame analyzer, and can be supplied to measure, record, and automatically control the heating effect of any gas. With it, gas companies, industrial plants using producer gas, and the many new plants supplying butane gas to small communities, are enabled to check and regulate the quality of their gas output with special reference to heating effect. If it be necessary to dilute a rich gas, or to enrich a lean gas, the flame analyzer equipment is said not only to make observation and recording of the quality of the output easy, but also to control the mixture automatically, so as to insure a uniform product. The accompanying cut shows the flame analyzer, together with the recording instrument and a pressure governor and gage controlling the flow of gas through the analyzer.

Balancing Machinery

Electrocon Corporation, New York, has introduced a new Vibroscope (Model 3) to meet the demand for an instrument with greater illuminating power than its Model 1. Model 3 has about five times the power of Model 1. The equipment (for detecting and removing machine vibration troubles) was described in an earlier issue.

High Power at Switching Speeds

The Heisler Locomotive Works, Erie, Pa., has combined the Diesel engine with Westinghouse electrical equipment to produce a new 60-ton, oil-electric locomotive that will pull a load equal to that of a 100-ton steam locomotive, indicating a drawbar pull of 47,800 lb., according to the crew of the dynamometer car in which the results were recorded. A test revealed that on a 3 per cent grade and 14-deg. curve the 60-ton locomotive pulled 149 per cent more load than an 81-ton superheated steam locomotive working under the same conditions of track and grade. The new locomotive was built specially to produce high power at switch-yard speeds. Among the construction features which accomplished that result are the single-drive shaft, running through the two motors to both front and rear trucks; also a gear ratio that makes possible the development of greater "useful horsepower." Two 180-hp. oil-burning Buda Diesel engines furnish the power.

Ironsides Company Sponsors Research Project

Battelle Memorial Institute, Columbus, Ohio, announces establishment of a research project sponsored by the Ironsides Company, Columbus, manufacturers of special lubricants. This project will comprise a study of the fundamentals of lubrication. Dr. Robert C. Williams will be in charge, under direction of Dr. H. W. Russell, chief physicist of the Institute.

Wire Screen Cloth Makers Organize

Some of the more important companies producing wire-screen cloth have formed the Wire Screen Cloth Manufacturers' Institute. George E. Watson, former sales manager of the Wickwire Spencer Steel Company, with offices at 74 Trinity Place, New York, is secretary.

BULLETINS

Diamond Drills, Supplies.—E. J. Longyear Company, Minneapolis, Minn. Catalog No. 8, of which 33 pages are devoted to useful information regarding use and selection of core-drilling equipment.

Driller's Handbook.—Cleveland Rock Drill Company, 3734 East 78th St., Cleveland, Ohio. A handsome, strongly bound book of pocket size, containing 122 pages, covering rock-drill development history, lubrication, operating, shanks and bits, hose and couplings, modern drill types, and explosives and blasting. This will be sent to anyone interested.

Rock Tunnel Methods. — Hercules Powder Company, Wilmington, Del. A 92-page, 9x12-in. book presenting data on drilling, blasting, excavating, transportation, ventilation, and lining on 31 tunneling jobs, including 7 mine tunnels.

Power Drag Scrapers. — Sauerman Bros., 438 S. Clinton St., Chicago. Catalog No. 14, covering wide ranges of scrapers up to 12 cu.yd. in size, with additional sections on tower machines and unclassified excavating work.

Heusser Laboratory Balances.—Mine & Smelter Supply Company, Denver.

Pulverizing Machinery. — Raymond Bros. Impact Pulverizer Company, 1302 North Branch St., Chicago. Résumé of equipment built and installed in 1930.

Respirators.—Pulmosan Safety Equipment Corporation, Brooklyn, N. Y. Circular describing more than 30 different types of respirators in industrial use. Many new developments are shown.

Molybdenum in Cast Iron.—Climax Molybdenum Company, 295 Madison Ave., New York.

CO_2 Recorders.—Brown Instrument Company, Philadelphia, Pa. Catalog No. 3004. Indicating and recording electric CO_2 meters.

Diesel Engines.—Worthington Pump & Machinery Corporation, Harrison, N. J. Vertical, 4-cylinder, direct-injection, 50-150 hp. Bulletin S-500-BS.

NEWS OF THE INDUSTRY

Mellon Opposes Embargo on Russian Manganese

Secretary of the Treasury Mellon made a formal statement on Feb. 24, declaring that issuance of anti-dumping orders against manganese ore imported from the Soviet Republic of Georgia is not justified. The evidence showed, according to Secretary Mellon, that the purchase, or exporter's, price to the United States is greater than the foreign market value as defined by the anti-dumping act of 1921.

Seymour Lowman, Assistant Secretary of the Treasury, previously had advised the Ways and Means Committee of the House of Representatives that importation of manganese could not be barred under the anti-dumping law nor under the provisions of the tariff law excluding the products of convict, forced, and indentured labor. He stated that there is no competent evidence that manganese is produced by such labor, and he pointed out further that the prohibition applies only to the importation of products produced in the United States in sufficient quantity to meet the domestic demand.

The House Ways and Means Committee has voted down the Williamson bill to prohibit importation of all products from Soviet Russia. But on the committee's recommendation, the House passed the Kendall bill to fortify the prohibition against importation of goods tainted with involuntary convict labor by extending the ban to include products not only mined, produced, and manufactured, but transported, handled, loaded, or unloaded by convict, forced, or indentured labor. The bill also would advance from Jan. 1, 1932, to April 1 of this year the effective date of the proviso against forced and indentured labor products and instruct the courts to accept as evidence that otherwise would be rejected as hearsay such information as Treasury agents may obtain indirectly regarding the status of labor employed. The Kendall bill was killed in the Senate Finance Committee on Feb. 25 by a vote of 8 to 6.

■

Fresnillo Cuts Ore at 560 M.

Crosscutting on the 560-m. level of the Fresnillo mine, at Fresnillo, Zacatecas, Mexico, has cut ore 12 ft. wide, averaging 6.9 per cent lead, 5.8 per cent zinc, 0.3 per cent copper, and 4.8 oz. of silver to the ton, at a distance of 1,070 ft. from the Saraos shaft. As the crosscut intersected the Cueva Santa vein at a point where little ore has been found above, the results are considered encouraging. Sinking of the East shaft has been completed to 560 m., and crosscuts are now being driven to the vein at that depth and at 515 m. Development on the 470-m. level through this shaft has been stopped, as it can now be done better through the Saraos.

Some ore with fairly good grade of copper is being opened on the 470-m. level, one winze, in fact, showing an average of 5.8 per cent copper over a width of 4.4 ft. for 248 ft. The east oreshoot has been opened for 624 ft. at this level and shows higher assays in all metals than any of the upper levels. On the west oreshoot, at 425 m., ore has now been proved for 1,804 ft.

■

Silver King Mine Increased Ore Reserves in 1930

Despite some curtailment in production as a result of the low metal prices that prevailed in 1930, development work at the Silver King Coalition lead-zinc-silver mine, at Park City, Utah, resulted in an additional tonnage of high-grade ore being developed and in materially increasing the ore reserves already blocked out. A total of 33,113 ft. of development work was completed at a cost of $526,792, compared with 33,105 ft., costing $513,497, in 1929. Only a small percentage of the company's holdings in the mineralized zone at Park City (which total 4,466 acres) has been explored. M. J. Dailey, general manager, believes a long productive life is assured, as work at depth has shown the orebodies maintain size and grade.

Mill efficiency continues to improve. In 1930, the mill handled 155,717 short tons, compared with 179,989 tons in 1929. Grade of lead concentrate improved from 62.5 per cent lead in 1929 to 64.6 per cent lead in 1930 and grade of zinc concentrate from 54.75 per cent zinc to 59.13 per cent. Because of the smaller tonnage, however, only zinc showed an increase in volume of production.

■

Giesche Cuts Output, Wages

Press reports state that Giesche Spolka Akcyina, which is controlled by Anaconda Copper and W. A. Harriman & Company, has obtained the consent of the Polish government to a 7 per cent reduction in wages of all workers at its zinc properties in Upper Silesia. About 20,000 men employed by the company there will be affected. In addition, the company is cutting its production by 30 per cent. Estimates for 1930 place the zinc output at 85,000 metric tons.

■

Government Positions Open

Positions with the U. S. Bureau of Mines and the U. S. Geological Survey for which open competitive examinations will be held within the near future include assistant mining engineer, and junior, assistant, and associate geologist. The entrance salaries, respectively, are $2,600, $2,000, $2,600, and $3,200 annually. Full information as to qualifications and date and place of examination may be obtained from the U. S. Civil Service Commission, Washington, D. C., or from the secretary of the U. S. Civil Service Board of examiners at the post office or custom house in any city.

Anaconda Contracts for Natural-Gas Supply

Anaconda Copper, after several negotiations had ended unsatisfactorily, signed contracts on Feb. 27 providing for a supply of natural gas to its mines and metallurgical plants at Butte and Anaconda, Mont. Montana Power at the same time signed a contract to distribute gas for domestic purposes. Louis B. O'Neill, a pioneer in oil and gas development, will lay a 230-mile pipe line from Cutbank, in northern Montana, to the mining district and agrees to provide a minimum of 10,000,000,000 cu.ft. of natural gas annually.

Construction of the line is expected to cost about $12,000,000. The pipe itself will be 20 in. in diameter and weigh 80 lb. to the foot. Branch pipe lines will serve communities in all directions where the Montana Power Company holds franchises. Compressor stations along the route will maintain a minimum pressure of 765 lb. to the square inch.

Considerable economies are expected to result from the use of natural gas as fuel at the Anaconda power plants and in the copper smelter. Pulverized coal is now used in smelting operations in the reverberatory furnaces.

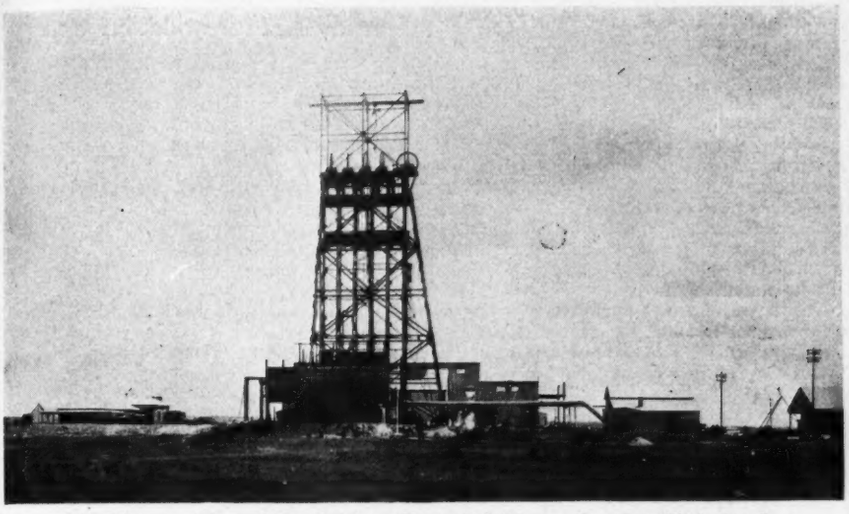
■

Park Utah Opens New Ore in Western Area of City Unit

Development in the western section of the City unit of Park Utah Consolidated Mines has opened new lead-zinc orebodies west of all ores previously found at this property, near Park City, Utah. At the end of the year the City unit, which produces about half of the company's total tonnage, had greatly increased ore reserves. On the other hand, work in the Utah unit has been discouraging. Continued search for the downward extension of both eastern and western orebodies in this unit has yielded no results, and the ore remaining in them has become limited, according to G. W. Lambourne, president of the company. Park Utah has been looking for ore on the 1,950 level of its Utah unit since early in 1929. Total expenditure on development in 1930 was about $270,000, compared with $334,389 in 1929.

Ore production dropped more than 40 per cent in 1930, from 300,931 short tons in 1929, to 171,750 tons. Because of the higher grade of ore mined, metal production did not show as large a drop.

On Feb. 27, Mr. Lambourne announced that work would be abandoned in the Utah unit of the property below the 1,800 level. He said present low prices of lead and silver render pumping of water and removal of ore below that level unprofitable. When metal prices improve, the 1,950 level will be unwatered again and exploration continued. Development of the mine will be continued above the 1,500 or tunnel level. About 100 men will be laid off after the pulling of the pumps is completed.



Headframe and surface plant at East Geduld, on the Far East Rand.
See p. 241 for cabled details on progress of mill construction

New Ahmeek Power Plant of C. & H. in Operation

Calumet & Hecla Consolidated's new auxiliary power plant at the Ahmeek stamp mill, near Lake Linden, Mich., has been completed, at a cost of close to $1,500,000, and is in operation. Stone & Webster, of Boston, who built the plant, will finish their contract this month. The plant consists of power house and boiler plant, the latter having a capacity of 180,000 lb. of steam, which supplies steam both for the stamp mill and turbines. Power capacity is 11,000 kw. per hour.

The new plant is supplementary to the main power station at Lake Linden, which has a capacity of 17,000 kw., and two smaller plants at the Ahmeek mill and the smelter at Hubbell. Calumet & Hecla now has sufficient power capacity for all future purposes, mining, milling, reclamation, smelting, exploration, and development work.

The new plant is one of the most modern operated by steam in the country, producing power at very low cost. At present, owing to curtailment of operations, less than half of the power load is required. Ample power at the lowest possible cost is provided by the combined plants.

Calumet & Hecla Consolidated is opening the Kearsarge lode from the point where it was cut at great depth in the 78th level east crosscut, 3,200 ft. from No. 12 conglomerate shaft. Copper content, which was heavy in the crosscut, is reported to be holding out encouragingly in the short distance drifted. As operations are being conducted only four days a week, progress necessarily will be slow.

■

Michigan Tech. Reunion

Graduates of the Michigan College of Mining and Technology will hold a reunion at Houghton, Mich., on Aug. 6, 7, and 8. This is one of a series of reunions held every five years by the school, according to Dr. W. O. Hotchkiss, president of the college. Announcement of the meeting was made at the annual alumni dinner on Feb. 17, in New York City. A total of 53 men attended the dinner, which was held at Keen's English Chop House and presided over by Scott Turner, Director of the U. S. Bureau of Mines, as toastmaster.

Lack of Funds Hampers Study of Farm Mineral Resources

Investigation by the U. S. Bureau of Agricultural Economics of the mineral resources of farm lands requested by Senate resolution adopted Feb. 26 cannot be undertaken, because of lack of funds, according to Dr. L. C. Gray, chief of the Division of Land Economics. The resolution, sponsored by Senator Thomas, of Oklahoma, did not carry any appropriation for the inquiry.

The purpose of the proposed investigation, as explained by Senator Thomas, is to establish the value of mineral resources as a farm asset with a view to the enactment of legislation to encourage co-operation among farmers in the exploitation of such resources. The prevalent discussions of farm relief, said Senator Thomas, have failed to give consideration to the mineral resources underlying millions of acres of farm lands. Senator Thomas expressed the conviction that farmers can safely capitalize their mineral rights and engage in "three-dimension" farming.

Mineral acreage considered as a farm asset, said Senator Thomas, does not exist merely in those states commonly recognized as productive of oil, gas, and other minerals, but, according to recognized authorities, exists in about 57 per cent of the area of the United States and in practically every agricultural state.

■

Mining Fellowships Offered

The department of mining and metallurgical research of the Utah Engineering Experiment Station, maintained by the University of Utah in co-operation with the U. S. Bureau of Mines, is offering five fellowships for the year 1931-1932. Incomes are $720 for the year beginning July 6 and ending June 4 Further information may be obtained from the director of the station, University of Utah, Salt Lake City, Utah.

The Engineering Experiment Station at the University of Illinois is offering a total of sixteen graduate assistantships, for research on various engineering problems, including mining and metallurgical. Incomes are $600 for the year beginning Sept. 1. Further information may be obtained from addressing the director of the station, at Urbana, Ill.

Hecla Ore Reserves Drop; Union Venture a Loss

Ore reserves at the Hecla lead-silver mine, in the Cœur d'Alene district of Idaho, were estimated at 2,004,808 short tons at the end of 1930, compared with 2,176,047 tons at the beginning of the year, according to J. F. McCarthy, president of the company. Ore extraction was 311,681 tons, indicating that development replaced less than half the tonnage mined. Most of the new work at the property recently has been in connection with improving haulage facilities on the 2,800 level. Total development footage driven in 1930 was 5,457 ft., compared with 6,030 ft. in 1929. Total operating expense, per ton of ore, was only $4.57 in 1930, compared with $4.77 in 1929. Substantial reductions were effected both in mining and milling costs per ton.

Production continued at the Union silver-gold mine in British Columbia, but development confirmed the theory that the bottom of the deposit has been reached above the No. 4 level. The orebody is small and will be exhausted during 1931 unless other deposits not now known are disclosed. The company has done a large amount of exploration along the dip and strike, but results have been disappointing. Even with the present low silver price, an operating profit is being made, but present indications are that a complete return of the capital that Hecla has invested in the mine will not be possible.

Development work on the Star mine of Sullivan Mining, in which Hecla has a half interest, has been continued since the mine closed in April, 1930. This work is now being gradually reduced and will within a short time be confined to a small crew to keep the mine in condition for resumption of output whenever metal prices justify. The Star is developed and exploited through the Hecla shaft.

■

Hoover Signs Bill for New Mines Building

Establishment of a new experiment station for the U. S. Bureau of Mines on the campus of the University of Maryland, near Washington, D. C., became a certainty with the signature by President Hoover on March 4 of a bill authorizing the project. Actual construction of the building cannot be undertaken until the recommended appropriation of $350,000 is authorized by the next Congress in December, but in the meantime complete title to the site will be conveyed to the federal government and the plans drafted for the new laboratory.

Only 8 miles distant from the Bureau's headquarters in Washington, the new laboratory will enable Bureau officials now engaged in administrative duties to supervise more closely the scientific and technical research that can be conducted only in the field. As most of the present field stations of the Bureau are located at points remote from Washington, the chiefs of divisions have been unable to devote as much time as they would like to research work in which they are particularly interested. The plan for locating a laboratory near Washington was advanced to permit the Bureau's administrative personnel, which is also expert in many branches of the mining and metallurgical industries, to carry on research under favorable conditions without interference with the discharge of their administrative duties.

United Verde Negotiates for Verde Central at Jerome

An offer made by United Verde Copper, at Jerome, Ariz., for the mine and mill of Verde Central, was considered at the annual meeting of the latter company on April 6. Verde Central, a small copper producer with properties near those of United Verde, is now controlled by Calumet & Arizona, said to be in favor of the proposal. The mine, which is in the Walnut Gulch section of the Jerome district, has been developed to a maximum depth of 1,900 ft. and is equipped with a 300-ton mill, which started operation in January, 1929, and ran until the middle of 1930, when it was closed because of low metal prices. United Verde is said to have offered $250,000 for the company's entire assets with the exception of certain current assets and cash.

Another Jerome property changed hands in February when G. W. Avery purchased the holdings of Calumet & Jerome Mining for about $25,000 at a sheriff's sale in Prescott, Ariz., on Feb. 21. Mr. Avery was president of the company and held several notes against it. Calumet & Jerome has been extensively developed, but has not yet reached the producing stage.

■

Waite-Ackerman Increases Copper Reserves Greatly

Reserves of copper ore at the property of Waite-Ackerman-Montgomery Mines, in the Rouyn district of Quebec, have been greatly increased by diamond drilling and underground exploration. On Dec. 31, 1930, they were estimated at 446,500 short tons, averaging 5.9 per cent copper, compared with 100,000 tons, averaging 6.1 per cent copper, at the beginning of the year. Reserves of zinc ore are unchanged at 300,000 tons, averaging 11.5 per cent zinc.

Development underground has consisted largely of crosscutting and drifting on the 500 and 700 levels to corroborate drill results. Two main orebodies, designated C and E, have been opened up. They have the usual flat dip of Waite orebodies to the southeast. Raising necessary to prepare the orebodies for stoping is under way, but regular production will not be attempted until the copper industry shows substantial improvement. Drilling below the 700 level has developed a new orebody, called the No. 8, which has not proved as large as at first anticipated.

■

Hollinger to Raise Tonnage Slightly, Timmins States

An increase in the volume of gold ore going to the mill from 4,500 to about 4,800 short tons daily is announced by N. A. Timmins, president of Hollinger Consolidated, in an interview with *The Northern Miner*. Although capacity is 8,000 short tons daily, the mill at Timmins, Ont., has been handling about 4,500 tons daily for the last few years as a result of a decrease in ore reserves. Mr. Timmins' statement indicates that the tide has turned, at least temporarily. Ore reserves were almost $49,000,000 in gold on Dec. 31, a gain of about $1,000,000 during the year. New development continues to open up more ore than is being extracted, Mr. Timmins states. Much of this ore is coming from extensions of veins in the upper levels which were only partly developed in the days when Hollinger was handling 5,000 to 6,000 tons daily.

Sinking of the Schumacher shaft to 6,000 ft. from its present depth of 4,000 ft. is contemplated by the company. Mr. Timmins characterized the results of work in the Schumacher section as "splendid." Continuation of these results from 4,000 to 6,000 ft. will assure the mine a long life, he stated. A major development campaign, however, will have to await the decision of Dr. L. C. Graton, of Harvard, who is preparing an exhaustive report on the mine. It is expected to be available late in 1931.

Study Lead Production Costs

Pursuant to the King resolution adopted by the U. S. Senate on Feb. 17, the Tariff Commission has undertaken an investigation into the comparative costs of producing lead in foreign and domestic mines. This includes only the lead ores and forms of lead covered in paragraphs 391 and 392 of the 1930 tariff. The inquiry will embrace mining, concentrating, smelting, and refining operations and possibly other phases of the industry. The commission's cost data will be submitted to the Senate upon completion of the inquiry without recommendation concerning rates of duty—now the equivalent of 2½c. a pound on refined lead.

■ ■ ■

Tri-State Output Falls as Mines Are Beset by Financial Troubles

Within the last two weeks production of concentrate in the Tri-State zinc-lead district has been cut about 15 per cent from the rate prevailing earlier in the year. The continued depression in metal prices has precipitated several of the larger companies into serious financial difficulties, Canam Metals being the most recent victim. In addition, the depression was probably responsible for the failure of Eagle-Picher Lead to exercise its option on the properties of Commerce Mining & Royalty, largest Tri-State producer. An estimate of ore reserves, made by 39 companies (producing 25 per cent of the district's output), indicates that sufficient material for about ten years at current production rates, or possibly slightly higher, is in sight.

Output of the district has been about 7,500 short tons of concentrate a week since the beginning of the year. With the failure of Eagle-Picher to exercise its option on their properties, however, the owners of Commerce Mining & Royalty have cut production in half. Of the eight mills formerly in operation, only four will be running at any one time. They will alternate at weekly intervals. This schedule will reduce the company's output from 2,000 to 1,000 short tons weekly. In addition, closing of the two mills that Canam Metals had been operating reduces current output 200 tons a week. Other operating companies with more than one mill still handling ore are expected to adopt the schedule in force at the Commerce properties.

Eagle-Picher Lead has filed suit in the circuit court of Jasper County, Mo., asking foreclosure on the several mining properties of Canam Metals, over which it holds a $450,000 promissory note on which $421,566.67 is due. Canam Metals purchased these properties from Childress Lead & Zinc and Frank Childress in 1928 for $1,050,000, of which $950,000 went to the Childress group. Canam paid $500,000 in cash and gave promissory notes for the remainder. When these fell due, Canam was unable to pay until Eagle-Picher refinanced the transaction. Failure to meet payments due Eagle-Picher on Nov. 1, Dec. 1, Jan. 1, and Feb. 1. has brought about the suit. Properties on which foreclosure is sought include the Southside, Constitutional, Midas, Fort Worth, Whitebird, Foch, Black Hawk, Golden Hawk, and Tri-State mines, in Oklahoma, the Fox and Northern, in Kansas; and leases on mining lands in Missouri.

Other mining companies in the district which are threatened with bankruptcy are the Missouri-Kansas Zinc Corporation, Oko Mining, and L. & G. Mining, now in the hands of receivers. Missouri-Kansas paid more than $1,000,000 for mining properties in the Waco district, near Joplin. C. Erb Wuensch, the ancillary receiver, has made a profit-sharing agreement with the employees which permits continued operation. L. & G. Mining and Oko Mining, owned by T. F. Lennan and associates, have liabilities of more than $600,000. All of their properties are now idle.

The 39 companies that estimated reserves included in their estimates available tonnages of mill residues that might be re-treated at a profit. Thus, although the average grade was not published, it is probably about 3 to 4 per cent zinc and less than 1 per cent lead. Their total reserves were put at 39,636,100 short tons. Production from their properties was about 5,000,000 tons in 1926—a prosperous year—and 3,000,000 tons in 1930. Assuming that these mines are representative of the field as a whole, indicated reserves—on a basis of 25 per cent—would be 160,000,000 short tons. Estimates include developed, probable, and possible ore. Further drilling in the field will undoubtedly add to this tonnage.

■

Brownell to Discuss Silver

Francis H. Brownell, chairman of the board of American Smelting & Refining, will address New York mining engineers on Thursday evening, March 12, on the subject: "Stabilization of Silver Without Legislation: Is It Possible?" General discussion will follow Mr. Brownell's address, and all who may be interested are invited. The meeting is scheduled for 7:45 at the rooms of the Building Trades Employers' Association, 2 Park Ave., and will be preceded by a dinner of the New York Section, A.I.M.E., at 6:45. Dinner reservations must be made through L. F. Strobel (Fitzroy 8-9668).

Union Copper Driving New Tunnel to Cut San Pedro Vein on Mill Level

Driving of a new tunnel on the mill level has been started at the property of Union Copper at Cobre, Aguascalientes, Mexico. This tunnel, situated near the mill and the collar of the San Pedro shaft, will cut the San Pedro vein at a short distance from its portal and will then be driven on the vein for about 2,600 ft. It will develop a large tonnage of low-grade ore through raises put up at regular intervals. Production from the property, which is probably the only Mexican copper mine to increase production within the last year, is now at the rate of 17,000 metric tons of ore monthly.

Union Copper was formed in 1929 by Henry Wyman to operate the Tepezala mines, owned by the Guggenheim interests, under a 25-year lease. Construction of a 300-ton concentrator was started immediately and it was put into operation in February, 1930. An additional 300-ton unit was put into operation in July of that year, but because of slight trouble encountered with one of the grinding units, capacity operation was not reached until the end of October. At present, the company is employing about 400 men in the mine, mill, and railroad. The production of 600 metric tons of ore daily is obtained from old mine fills and from a low-grade surface dump as well as from new stopes. The grade of mine ore is about 3.5 per cent copper, mine fills are about 2 per cent copper, and dump material is 1 per cent copper. Average grade of mill heads is 1.3 per cent. A concentrate averaging about 22 per cent copper is produced.

Development of the mine has been conducted largely through the San Pedro shaft. This is a two-compartment, steel-lined unit, bottomed at 600 ft. It is equipped with a 125-hp. Wellman-Seaver-Morgan two-drum electric hoist. The compressor unit is a 440-hp. Ingersoll-Rand synchronous-motor compressor, and drilling equipment includes Ingersoll-Rand and Chicago Pneumatic rock drills. A Cameron pump, handling about 250 g.p.m., keeps the workings unwatered and supplies the mill with all its water requirements. Electric haulage has not yet been installed underground, but equipment has been purchased and will soon be put into use.

Recently the company reopened the old Tiro Azul shaft, which had been closed down for many years. It is bottomed at about 150 ft. A strike of high-grade ore has been made in the bottom level, and development is now being pushed on a three-shift basis. The ore runs 4 to 26 per cent copper. To facilitate development work at the Tiro Azul, a headframe has been constructed and a 50-hp. Wellman-Seaver-Morgan single-drum electric hoist has been installed. All development work is done on a contract basis.

Dump material is handled by three-drum Sullivan slushers and is hauled to the mill over a 24-in. track. A 2½-ton Whitcomb gasoline locomotive is used.

At the mill, the equipment includes a 20x24-in. Allis-Chalmers jaw crusher; a 4-ft. Symons cone crusher; two No. 86 Marcy ball mills (8x6 ft.); two 6x21-ft. Dorr drag classifiers; four 20-ft. McIntosh flotation machines; two 10-ft. McIntosh flotation machines, acting as cleaners; a Dorr thickener; and a three-leaf 4-ft. American filter. In addition to the copper content, concentrate averages about 1,300 oz. of silver to the ton.

Concentrate is shipped to the San Luis Potosi smelter of American Smelting & Refining over the company's 11-mile railroad, which joins the main line at Rincon de Romas. This road is operated under the same lease agreement as the mine. Equipment includes a 9-ton Whitcomb gasoline locomotive, operating on standard-gage track, and fourteen box cars.

Power for the operations is obtained from the plant of Minerva Mining, at San Gil, Aguascalientes. Union Copper built a 3½-mile transmission line to connect with the Minerva main line. At present about 650 to 700 kw. is required for operating purposes, but when electric transportation is installed underground a larger amount will be needed.

In spite of the present low prices of copper and silver, the company has made an operating profit every month since production started.

The Tepezala mines have been worked since the time of Cortez, Spanish conqueror of Mexico, and not fewer than seventeen shafts have been put down on different parts of the properties. The most recent attempt to operate them, previous to acquisition by Union Copper, was by Aguascalientes Metal, which also operated under lease from Guggenheim Smelting. Lack of milling facilities was said to have been the chief reason for suspension in 1927.

■

All Operations Suspended at Santa Maria de la Paz

Operations were completely suspended at the Santa Maria de la Paz mine, at Matehuala. San Luis Potosi, Mexico, on Feb. 26, as a result of the continued low price of silver. The property was the largest producer in the district, employed 1,600 men, and had produced about 5,000,000 oz. of silver annually in 1929 and 1930. It had been operating for seventy years. Application to suspend was made in the summer of 1930, when the price of silver dropped to below 40c. an ounce, but the government refused the necessary permission. A 20 per cent wage cut was agreed upon instead. Even this concession, however, was not sufficient to offset the continued decline in the price, and the government was finally obliged to consent.

As the Dolores mine, the other large producer in the district, has also closed, American Smelting & Refining will probably be forced to shut down its Matehuala smelter within a short time, although the plant still is in operation. Kildun Mining, also operating in this district, is shipping gold-silver ores to the San Luis Potosi smelter of A. S. & R.

To aid silver producers in meeting the present crucial situation, the Mexican government has made a downward revision in its production tax on the metal. Effective March 1, silver produced by smelters and flotation plants will pay only 2.5 per cent of its value in taxes, instead of 6 per cent as formerly. Silver produced by cyanide plants is already on the reduced scale.

Ahumada Continuing Drift to Explore Eastern Area

Although the exploration work undertaken in the western section of the Ahumada Lead property, in the Los Lamentos district, Chihuahua, Mexico, yielded no results sufficiently encouraging to warrant continuation of the work, drifting east on the No. 5 level is being continued, according to J. M. Brooks, Jr., manager. No ore has yet been opened in the drift, but several mineralized areas were encountered.

In addition, the company is attempting exploration of its known orebodies on the No. 8 level through a winze recently put down in the northwest section of the property. This winze will open ground that is not expected to carry the heavy water flow that has handicapped No. 8 level operations through the main shaft. Work on No. 8 level had to be suspended last year because the low price of lead did not permit meeting the high pumping charges that resulted from the water flow of more than 3,000 g.p.m.

Output from the adjoining Erupcion lead mine is coming from a small extension of the main orebody. Development has yielded discouraging results, but the company hopes to maintain a small output from this source for some time. Further expenditure for exploration is not thought justifiable.

■

Cusi-Mexicana West Orebody Shows High-Grade Ore

Between the "A" level and the Santa Marina tunnel level at its properties, Cusihuiriachic, Chihuahua, Mexico, Cusi-Mexicana Mining has opened ore 10 ft. wide, averaging more than 100 oz. in silver to the ton, with some gold, according to H. C. Dudley, president of the company. This ore is in the West orebody, which has been developed largely within the last year. It tends to lend confidence to the company's belief that at some point in the property a silver bonanza may be found similar to the Promontorio bonanza, discovered in an adjoining mine. The West orebody has now been developed over a vertical extent of 300 ft. It has a length of 460 ft. on the Providencia level, the lowest on which it has yet been developed, and a width of 8.2 ft. According to present indications, about 200,000 metric tons of ore has been proved above the Providencia level.

Operations at the property are now restricted to handling sufficient tonnage to pay operating costs, without unduly depleting ore reserves. Shipment of zinc concentrate has been suspended for the last year, since present prices would not cover transportation and recovery costs. As far as possible, stopes carrying comparatively high zinc content are being left intact and production is obtained from the leady sections of the orebodies. The average grade of sulphide ore at the property is about 4.3 per cent lead, 5.4 per cent zinc, and 21 oz. of silver to the ton.

Total underground development done during 1930 amounted to 3,005 m., compared with 2,186 m. in the preceding year. In addition to development of the West orebody, which now furnishes the greater part of present mine tonnage, considerable work was done on the South orebody, which was cut on the "A" level, but apparently pinches out below the Santa Marina tunnel. To the southwest the company will develop under the old Santa Eduwiges workings.

The fertilizer unit built by Consolidated Mining & Smelting at Trail, B. C., to utilize byproduct sulphuric acid

Freeport Texas to Build Plant at Cuban Manganese Mines

Construction of a 1,000-ton beneficiation plant will be undertaken by Cuban American Manganese, as a result of the negotiations whereby Freeport Texas has purchased a controlling interest in the company, operating properties near Santiago, Cuba. Freeport Texas, which has heretofore been interested chiefly in production of sulphur, hopes by this move to furnish an additional near-by supply of manganese for the domestic steel industry.

Production of the first plant unit is expected to be 100,000 long tons of manganese ore with a grade of 50 per cent Mn. Operation will probably start within a year. The process used has been developed by engineers of Freeport Texas and B. F. Goodrich Company, which has a minority interest in Cuban American Manganese. A total of 10,000 acres of ground, in five principal groups, are held by the company. Manganese can be shipped to the United States market free of duty, under the commercial treaty made with Cuba in 1902.

■

Development on 3,650 Level Adds to Morning Reserves

Development work on the 3,650 level, which was partly opened up during 1930, increased reserves of lead-zinc ore at the Morning mine of Federal Mining & Smelting, near Mullan, Idaho, by 65,750 short tons during the year, despite extraction of 361,372 tons—indicating development of about 427,000 tons in the 200 ft. intervening between the 3,450 and 3,650 levels. Ore reserves at the end of the year are estimated at 1,720,700 tons by H. G. Washburn, general manager of the company. Diamond drilling has indicated additional ore below the 3,650 level, but "possible ore" is not taken into account in estimating the reserves. Grade of ore treated during 1930 did not change greatly and, although production is now curtailed, the mine is in excellent condition.

■

Nevada Asks Aid for Metals

The Branson resolution memorializing Congress to pass a copper tariff was passed by the Nevada Assembly at Carson, Nev. The state Senate passed a resolution endorsing the calling of an international conference to stabilize silver prices.

BRIEF NOTES

Arrowhead Gold Mining. Sinking of two prospect shafts at Yucca Grove, San Bernardino County, Calif., has been started by the company, organized by W. F. Snyder & Sons, of Salt Lake City. Gold quartz has been found on the surface here. J. C. Ingersoll, geologist, is in charge of the preliminary work. Death Valley Gold, also backed by Utah capital, is trenching on its claims in the district.

Calumet & Arizona. The new hoist house and foundations for the new electric hoist at the Junction shaft, near Lowell, Ariz., have been completed. The machinery is expected to arrive early in March. At the company's smelter, the new 295-ft. steel stack, made by the Kansas City Steel Company, has been put into use. The outer shell measures 25 ft. in diameter and the diameter between the inside brick lining is 20 ft. The old stack will be repaired and used as a stand-by.

Easy Money Mining. The company has purchased the old Hamilton mill, in the Crestline section of the Tri-State district, and will move it to the 80-acre lease, north of Diamond, Mo., about 16 miles southeast of Joplin. Considerable development has been done on the Easy Money lease during the last few months.

Eureka Standard. Shaft sinking has been resumed at the property in the East Tintic district of Utah after installation of a Cameron sinker pump. A flow of about 300 g.p.m. was struck at a depth of 1,420 ft. The water has a temperature of 135 deg. F. The pump lifts water to the 1,300 level, where it is handled by a Cameron centrifugal pump. A connection has recently been completed between the Eureka Standard 1,300 level and the Iron King 1,450 level. Shaft sinking will be continued to 1,500 ft.

Falconbridge Nickel. Stoping on the 350 level of the mine, near Sudbury, Ont., has shown greater widths and more continuous ore than was expected. Average width is about 25 ft., and in places stoping has shown ore to be 40 ft. wide. Production is being maintained at about 300 short tons daily, despite a lessened demand for nickel.

Granada Rouyn. Development on the 625 level of the mine, in the Rouyn district, Quebec, has yielded better results than that on any of the upper levels. A total of 640 ft. of ore has been opened on the No. 2 vein at this depth, compared with 345 ft. on the 500 level. Average grade of ore going to the mill is about $14 per ton. Production is still about 75 short tons daily. Because of the favorable developments at depth, new mining equipment may be ordered, as the present equipment is taxed to capacity. In fact, rumors are heard that a large American mining company is negotiating for control.

International Mining Exchange. In a note appearing in these columns in the Feb. 23 issue, it was stated that the company is a direct representative of the New York Mining Exchange. H. S. Thayer, vice-president of the New York exchange, writes to point out that his organization has no direct representatives. The error is regretted.

International Nickel. Dominion Bridge, of Montreal, has been awarded the contract for 3,500 tons of structural steel, together with a contract for erecting the steel superstructure of the new building at Copper Cliff, Ont., which will house No. 1 separation unit. At present this unit, used to separate copper from nickel in the matte, is at Port Colborne. Concrete foundations have already been completed by Fraser Brace Engineering. Erection of steel will start about March 20.

Jack Waite Mining. Operation of the new 500-ton mill at the property, in the eastern section of the Coeur d'Alene district, Idaho, is now on a basis of 350 short tons of lead-zinc ore daily. The plant was started on Feb. 1. About 75 tons of lead concentrate and high-grade lead ore is being shipped daily. Zinc concentrate production is relatively small, as the ore now being handled is from the lead sections of the orebodies.

Mexican Corporation. At its Teziutlan unit, Puebla, Mexico, the company has cut the Minerva orebody twice on its 370-m. level. The intersections showed ore averaging 3.7 per cent copper, 16 per cent zinc, and 3.7 per cent lead over a width of 13.5 ft. in one face, and 4.3 per cent copper, 23.3 per cent zinc, and 3.2 per cent lead over the same width in the other. These results are very gratifying, as they more than confirm the diamond-drill indications. Drifting on the orebody is now under way and should furnish a substantial proportion of the 160 short tons being milled daily.

(Continued on p. 242)

EXCLUSIVE

CABLES

FROM CORRESPONDENTS IN THE PRINCIPAL MINING CENTERS

Mount Isa Now Expects to Start on April 15

Melbourne, Feb. 28.—Operations at the Mount Isa lead-zinc property, in northern Queensland, are now expected to start on April 15. It will be some time, of course, before full-scale production of 2,000 long tons daily is reached. The company expects to employ about 900 men in its mine, mill, and smelter when going full blast. Mount Isa will then be the largest producer of lead in Australia, and, in view of the temporary curtailment at Broken Hill, may well be the largest producer of silver and of zinc concentrate as well. Although the average grade of zinc content for the entire mine is about the same as that of the lead content, zinc production will be comparatively small at first, because most of the ore will come from the lead-carbonate orebodies.

. . . . A nugget weighing 62 oz. and valued at £311 has been found at Blackwood, Victoria. Although this find cannot, of course, compare with the "Golden Eagle," recently found at Larkinville, Western Australia, it is one of the largest finds made in Victoria gold fields in recent years. Production for the state in January, 1931, was 2,247 oz.—double that of January, 1930. Evidently the intensive prospecting, with government assistance, and the prospect of the gold bonus, have stimulated production from this once-important gold-producing area.

. . . . The trial run of the grinding section of the new mill at Wiluna Gold, in Western Australia, has been very satisfactory, according to reports received here. Stoping on a small scale has started and the ore bins are now filled. The flotation plant and the roasters are expected to be ready for operation by the middle of March. Numerous additional technical appointments have been made to the Wiluna staff.

. . . . Tasmania metal production in 1930 was valued at £1,270,114, according to a preliminary estimate released by the state. This represents a decrease of £520,000 from 1929, most of it resulting from the great shrinkage in prices of copper, zinc, silver, and tin rather than a drop in volume of output. Electrolytic Zinc recovered a total of 53,958 long tons of zinc at its plant at Risdon and 224 long tons of cadmium. This byproduct was valued at £76,275.

. . . . Zinc Corporation, one of the three mining companies still in operation at Broken Hill, New South Wales, has given the labor unions two months' notice that operations at its properties will cease on April 25. This will leave only North Broken Hill and Broken Hill South in operation. Neither of these companies is recovering the zinc content of its ores, although lead production is being maintained at capacity. North Broken Hill will not pay a dividend for the quarter ending March 31. Broken Hill Associated Smelters, operating at Port Pirie, is negotiating for a reduction in wages. This plant, said to be the largest lead smelter in the world, treats nearly the entire Broken Hill output and has, of course, been adversely affected by the reduced output. The company desires to reduce wages 1s. 9d. per day to a base rate of 13s. 2d.

. . . . Broken Hill Proprietary, which was forced to close its lead mine last year because of low metal prices, is reported to be most anxious to develop a large, low-grade gold property and has several scouts in the field.

■

Norway Gets Contract for Russian Aluminum

Berlin, March 1.—The contract for delivery of wirebar aluminum to Russia from plants in Norway, including the Aluminum Company of America's subsidiary there, has been completed. Russia will receive 9,500 to 11,500 metric tons of aluminum annually for high-voltage purposes. The Norwegian government will guarantee 75 per cent of the price to the aluminum companies in case of default by Russia.

. . . . World copper output in January is estimated by the Metallgesellschaft at 117,632 metric tons, compared with 123,228 metric tons in December. Copper is now selling buoyantly here. Copper Exporters, Inc., at Brussels are willing to sell as much as 4,000 tons daily, which is far in excess of the quota allotted a month ago.

■

Victoria Prospecting Obtains Grant in Southern Rhodesia

London, Feb. 27.—Dougal Malcolm, presiding at the annual meeting of the shareholders of British South Africa, announced that the opposition of the government of Southern Rhodesia to the granting of large exclusive prospecting concessions, such as those now in force in Northern Rhodesia, had been withdrawn. As a consequence, the company is now able to grant the Victoria Prospecting Company exclusive rights over an area of 9,000 square miles. The capital of this company is held by important Rhodesian and Witwatersrand mining interests. One of the provisions of the grant is that not less than £20,000 be spent in two years for bona fide prospecting.

. . . . Although the tin-restriction scheme adopted by the Federated Malay States and Nigeria has been approved in principle by the British government, the market remains skeptical. It is not believed that the involved quota method of limiting shipments can be made to work smoothly. London Tin Corporation, operating mining properties in Nigeria, reports a net profit of £274,290 in the year ended Sept. 30, 1930, an increase of £137,255 compared with net in the previous fiscal year of £137,035. The increase is caused mainly by the great expansion in the company's interests, and partly by selective mining of the deposits. Because of the decline in the price of the metal, the company is conserving its resources rather than pay dividends.

. . . . Interest in gold mining in West Africa is reviving, particularly with reference to the Gold Coast. Taquah & Abosso and Cinnamon Bippo, its subsidiary concession, will both probably be included in the extensive scheme of development which will follow the report of Dr. Malcolm Maclaren on the field, to which reference was made at the recent meeting of Ashanti. Better transportation facilities, use of powered rock drills instead of hand drills, and cheap power are expected to lower costs and make possible the mining of increased tonnages of ore.

■

East Geduld Mill Progressing; New Ore at Crown Diamond

Johannesburg, Feb. 27.—Construction of the crushing section of the new East Geduld plant, on the Far East Rand section of the Witwatersrand, is now nearly complete. In the main milling unit of this important new gold enterprise, which will have a monthly capacity of 60,000 short tons, the three primary and four tertiary tube mills are now installed. East Geduld, following the success of West Rand Consolidated with a gyratory crusher, is installing three 7-in. Style "B" Newhouse gyratory crushers as a secondary crushing unit in its plant. Daggafontein Mines, which has started work on a mill to have a monthly capacity of 50,000 short tons, and Robinson Deep, on the Central Rand, which has been remodeling and enlarging its mill since the merger last year with Village Deep, are also installing Newhouse crushers in their plants.

. . . . An important enlargement of the diamondiferous pipe exploited by Crown Diamond Mining & Exploration in the Kroonstad district, Orange Free State, is reported at a depth of 1,100 ft. Crown Diamond formerly operated the mine through open-pit methods, but in April, 1926, it was decided to adopt underground mining. A vertical shaft has been sunk to 1,180 ft. and has opened levels at intervals of 40 ft.

. . . . Attention is now being paid to the lepidolite deposits in Namaqualand and British South West Africa, because of their comparatively high lithium content. Consumption of the metal—which is used largely as an alloying element in bearing metal and as a de-oxidizing agent in copper refining—is small and its production comes largely from Saxony, France, and the United States. Lepidolite as a rule contains lithium ranging from 0.8 to 2.7 per cent.

. . . . A new gold discovery is reported near Wedza, in Southern Rhodesia. Of importance to gold miners is the interim report of the Commission on Low-Grade Ore of the Witwatersrand, which is expected in a few days. This report is prepared for the use of the government and the industry on such questions as taxation and phthisis compensation.

Rhodesian Selection Transfers Grants to Mufulira Copper

London, Feb. 28.—Rhodesian Selection Trust, exploration and holding company with extensive interests in Northern Rhodesia, has transferred all the grants which it holds under the terms of the N'Kana Concession—22 in number—to Mufulira Copper in exchange for shares in that company. Mufulira was itself first developed by Rhodesian Selection, but when drilling indicated the size of its deposit, a separate company was formed and floated, in which Rhodesian Selection Trust, Bwana M'Kubwa (now a part of Rhodesian Congo Border), and British South Africa held most of the shares. Rhodesian Selection Trust had the privilege of selecting favorable areas within the N'Kana Concession until the beginning of 1930. In addition to Mufulira, the most important deposits found by the company were the Chambishi and the Baluba, adjoining the Muliashi claims of Roan Antelope. An agreement has been made with British South Africa that further assessment work on the grants may be deferred five years.

. . . . According to the report of British South Africa, the reserves of ore in the Mufulira mine proper are now estimated at 102,000,000 short tons, averaging 4.4 per cent copper. In addition, the Chambishi and Baluba deposits have outlined at least 45,000,000 tons of ore, bringing the company's known reserves up to 147,000,000 tons, averaging 4.15 per cent in sulphide copper. Because the percentage of oxide copper in these deposits is small, little effort will be made to recover it. Present known ore reserves in Northern Rhodesia are estimated by British South Africa at not less than 449,000,000 short tons averaging 4 per cent copper—an indicated copper content of 18,000,000 short tons.

. . . . Mufulira is making excellent progress in erection of surface equipment, power plant, townsite, and concentrator (capacity 5,000 short tons daily). No smelter will be built, concentrate being shipped to the Roan Antelope smelter. Negotiations are now under way for construction of a railroad from the Chambishi mine to Mufulira. Although the extension of the railroad from N'Kana to N'Changa will pass near the Chambishi property, evidently the Mufulira company desires to insure direct connection between its own mines. Possibly some of the higher-grade Chambishi ores will be shipped to Mufulira for concentration.

. . . . British South Africa is authority for the statement that Roan Antelope will begin to handle ore in its new mill, of which the first 5,000-ton unit is now nearing completion, within a few weeks. It may be some time before Roan copper appears on the market—unless the company ships its concentrate to Europe for smelting—as work on the smelter is not quite so advanced and the plant probably will not be in operation earlier than October. As for the date when the two other concentrators now being constructed in Northern Rhodesia will be put in operation, reports are conflicting. One report states that both N'Kana, owned by Rhodesian Congo Border, and Mufulira will start about the end of 1931. Another states that the N'Kana mill will not be ready until the middle of 1932. Ore from the N'Changa and N'Changa Extension mines of Rhodesian Congo Border will be shipped to N'Kana for milling. Two new drill holes have cut ore at the latter properties—Border NE 56 and N'Changa B 42.

. . . . In December, according to a report just issued, Roan Antelope drove a total of 8,115 ft. of new openings, bringing the total of development work done during the last quarter of 1930 to 21,023 ft., or nearly one-third of the 68,145 ft. of underground development done at this mine to date. The company is putting the finishing touches on mill and on power-plant construction and reports indicate that it has a plentiful supply of native labor.

. . . . Only 35 miles of steel will have to be laid to complete the linking of the Rhodesian and Belgian Congo copper mines with Lobito Bay by the new Benguela railroad. At least one of the Northern Rhodesian companies—Rhodesia-Katanga, operating the Kansanshi mine—will use the Lobito Bay route for transportation of production and supplies, thus avoiding the longer route through the Suez Canal and the Mediterranean Sea.

■ ■ ■

Brief Notes

(Continued from page 240)

Mohawk Mining. Sinking of the "E" shaft at the Michigan mine, in Ontonagon County, Mich., is continuing. The company hopes to begin lateral development on the 2,000 level by midsummer. This work will open up the Butler lode, which has been the most productive of the copper lodes in Ontonagon County. Mohawk owns 6 miles along the strike of the lode, including the former Mass Consolidated property.

New Bingham Mary. Control of the company has been purchased by Utah-Apex, which owns adjoining ground at Bingham, Utah. By terms of the agreement, Utah-Apex paid off the mortgage on the New Bingham property. Development will be conducted through Utah-Apex workings, but the separate corporate identity of the companies will be maintained. Most of New Bingham's production has come from the 1,000 and 1,100 levels. Utah-Apex has developed a new orebody on the 3,100 level to within a few feet of the New Bingham line.

Parkhill Gold Mines. A 75-ton cyanide plant will be built at the property, near Michipicoten, Ont., under the direction of James Grant and G. C. Burnham. It is expected to be complete by June 1. The company has developed a small tonnage of ore of good grade at the mine. In addition to this property, Parkhill has recently acquired nine claims at Hawk Junction, on which surface work is now starting.

Pend Oreille. Shipment of zinc concentrate to the East St. Louis plant of American Zinc, Lead & Smelting has been started. The company resumed operation of its Josephine concentrator, in the Metaline Falls district of Washington, last December, but at the time shipped only the lead concentrate as a satisfactory concentrate could not be arranged for the zinc. Since then the agreement with A. Z. L. & S. has been completed, and about a carload of concentrate daily will be shipped. Milling is at the rate of 200 short tons daily.

Shattuck Denn Mining. Estimated ore reserves at the company's Denn mine, in the Bisbee district, Arizona, were about the same at the end of 1930 as at the beginning, according to J. G. Flynn, superintendent of the mine. Development done in 1930 was nearly all confined to the 2,100 and 2,200 levels and consisted of 7,478 ft. of drifting, 1,500 ft. of raising, and 2,715 ft. of diamond drilling. Since the close of the year, diamond drilling is reported to have disclosed a large body of ore, averaging 5 per cent copper, south of the shaft and at a depth of about 2,350 ft. Drilling on this find is being continued. It extends into Calumet & Arizona ground. At the Shattuck mine, development has been suspended.

Sidney Leasing. A strike of lead-zinc-silver ore has been made on the surface of the Sidney mine, in the Coeur d'Alene district, according to Leslie Gay, manager of the mine. A short tunnel is being driven to ascertain its width and dip. Remodeling the tramway, connecting the mine with the Sweeney mill, has been completed, and the company is now prepared to resume shipments, at an increased rate, whenever metal prices improve. About 150 short tons daily were shipped during 1929 and early in 1930.

Stoody Company. Foundations for the mill which the company is building at the Boriana tungsten mine, near Yucca, Ariz., have been completed. The company has sunk a 130-ft. well to provide the mill with water and has completed a 6,000-ft. pipe line. In the mine the main haulage tunnel is being straightened out. About 40 men are employed.

Sullivan Mining. The tonnage of zinc produced from the company's electrolytic zinc unit near Kellogg, Idaho, has been increased from about 15 to from 25 to 30 short tons daily, or nearly half the plant's capacity. Production from the adjoining cadmium-recovery unit, however, has been suspended as a result of the drop in the price of cadmium to 55c. a pound. Increase in zinc production is said to result from the accumulation of concentrate rather than from a belief that the zinc market will improve. The proposed kilowatt tax on power generated in the state has aroused the company's opposition, as any increase in power costs might necessitate closing of the plant.

Tonopah Belmont. The company has optioned the Penales group of gold claims, near Duluth, in northern Nye County, Nev. A shaft has been put down to 100 ft. on these claims and a vein 5 ft. wide is said to have been developed.

United Verde Extension. The company must pay damages totaling $3,552.50 to ranch operators in the Upper Verde Valley, near its smelter at Clemenceau, Ariz., according to a ruling just handed down by the Supreme Court of Arizona. This ruling affirms the decision of the Yavapai County Supreme Court in the suit, which was started in December, 1927, by nine ranchers. Claims of four were dismissed.

Utah Ophir Mines. The company's Bingham Ophir tunnel is being driven to prospect fissures in Soldier Canyon, Tooele County, Utah. At present, the face of the tunnel is about 500 ft. from its portal. The first main fissure is expected to be cut within 200 ft.

MARKET AND FINANCIAL NEWS

International Tin Agreement Announced in London

The international plan to regulate production and shipments of tin for a period of two years, effective March 1, 1931, was officially announced in London on Feb. 28. Complete agreement was arrived at regarding the system of regulation to be adopted. The plan is to be administered by a committee representing the governments of Bolivia, Malaya, Netherlands East Indies, and Nigeria. The object of the arrangement is to secure fair and reasonable equilibrium between production and consumption with a view of preventing repeated and severe oscillations of prices. The basic world tonnage of tin under the plan was agreed upon at 145,000 long tons a year.

Initial quotas of the four principal producing countries have been fixed at 125,773 long tons a year, divided as follows: Malaya, 53,853 tons; Bolivia, 34.260; Netherlands East Indies, 29,910; Nigeria, 7,750. Invariable percentages based on these initial quotas were agreed for each country as ratios applicable to all alterations of basic tonnage. It was also agreed that (apart from special agreement arrived at in view of urgent circumstances) these initial quotas should remain fixed for a period of not less than six months.

Each government agrees to allot its national quota among the individual producers and to control production and export effectively in accordance with the plan.

The quotas may be altered from time to time, as circumstances may require, by unanimous consent of the participating governments. The quotas will in no circumstances be altered at shorter intervals than three months.

Sir John Campbell presided. The following delegates were present: Bolivian delegation, Antenor Patiño and Ricardo Martinez Vargas; Netherlands East Indies delegation, A. Groothoff, F. J. Houwert, and J. Van Den Broek; Nigerian delegation, Sir Frank Baddeley and Sir John Campbell; Malayan delegation, H. W. Thomson, and Sir John Campbell.

Also present were Sir P. Cunliffe Lister, the chairman, and John Howeson, C. V. Stephens and Henry Waugh, members of the council of the Tin Producers' Association; Sir R. Redmayne, chairman of the advisory council of the Mineral Resources Department of the Imperial Institute, and K. N. Lazarus, W. D. Ellis, J. A. Calder, and A. Layton.

■

Howe Sound Net Lower

Despite increases in production, Howe Sound, operating properties in Canada, Mexico, and the United States, reports a decrease in operating profit in 1930 as a result of low metal prices. It amounted to $3,214,203, compared with $5,146,563 in 1929. After depreciation and taxes, the net profit was $2,030,292 in 1930, $3,662,476 in 1929. The company maintained a substantial proportion of current assets—$7,748,486 at the end of 1930, compared with $8,330,876 at the end of 1929. Total assets were put at $19,366,240. Gross value of production was $13,210,459. In 1929 it was $16,346,101.

■

Shattuck Denn Mining

Net income of Shattuck Denn, operating a copper property at Bisbee, Ariz., dropped from $554,480 in 1929 to $123,780 in 1930. These figures are after tax deductions, but before depletion or depreciation. Gross value of production was $1,458,210 in 1930. The surplus at the end of the year was $3,857,181, compared with $4,034,461 at the beginning of the year. Total assets are put at $8,565,624, of which $1,675,506 is current assets.

A. S. & R. Earnings Dropped 50 Per Cent in 1930

Net profit of American Smelting & Refining, largest smelter and refiner of non-ferrous metals, was adversely affected by lower metal prices in 1930 to the extent of 50 per cent of the 1929 profit—the annual report giving the 1930 profit as $11,098,751, compared with $21,831,583. Operating profit was reduced from $32,659,728 in 1929 to $19,750,289. As dividends were maintained and stocks of metal on hand increased, the company's profit-and-loss surplus was decreased from $44,281.168 at the beginning of the year to $37,540,618 at the end.

The value of metal stocks, less unearned treatment charges, was $42,816,602 at the end of the year. Total current and miscellaneous assets were put at $87,013,298, and, with the capital assets, made a grand total of $237,165,597. Production, including metal treated on account of others, was 440,784 short tons of copper, 66,040 tons of zinc, 497,832 tons of lead, 1,760,702 oz. of gold, and 85,515,993 oz. of silver.

■

WAITE-ACKERMAN-MONTGOMERY, operating a copper-zinc mine in Quebec, Canada, reports a net loss of $4,704 during 1930, compared with a profit of $565,020 in 1929. Operating profit in 1930, before depreciation charges, was $33,739. Gross value of production was $116,916 and the total assets on Dec. 31, 1930, were put at $1,070,932.

World Production of Copper

American Bureau of Metal Statistics

Copper production of the world, based on copper content of blister as reported by the smelters, without segregation according to countries of origin, in short tons, follows:

	1930						1931
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
United States	67,638	66,698	68,487	70,419	64,816	60,022	53,429
Mexico	4,968	4,812	5,078	5,403	3,955	4,656	4,489
Canada	11,820	12,850	12,015	8,573	7,678	9,508	8,852
Chile and Peru	23,328	26,937	26,374	27,836	22,580	20,752	24,064
Japan	7,365	7,314	7,590	7,601	7,631	7,196	7,003
Australia	878	1,548	1,832	595	1,535	1 020	300
Germany	4,632	5,784	5,429	6,017	6,419	5,798	5,353
Other Europe (a)	12,900	12,700	13,000	13,200	12,900	13,000	12,500
Elsewhere (b)	15,400	16,100	16,900	17,700	15,700	14,300	13,400
Totals	148,929	154,743	156,705	157,344	143,214	136,252	129,390

(a) Partly estimated. Includes production of blister in countries other than Germany, whereof Spain, Russia, Yugoslavia, and Great Britain are the more important.
(b) Chiefly Africa; partly estimated.

Note: Totals under "Other Europe" and "Elsewhere" have been revised. The world's total for 1930, therefore, is 1,806,642 short tons and not 1,769,635 tons, as previously stated.

European Zinc Producers Slow in Curtailing

INTERNATIONAL METAL SERVICE, LTD, LONDON

The action of the European market for zinc has been disappointing. Recent statistics indicate that the effect of the contraction in ore supplies is not showing up in a definite curtailment of metal output. Belgium, according to latest advices, is not operating at more than 70 per cent of capacity, but there is good reason to believe that ore supplies on hand in that country are such as to enable production to continue at the current rate for several months. Poland has been moving rather slowly in applying the brakes on production, and the reductions made by other countries have not been sufficient to have any real influence on the position of zinc. Financial considerations, in all probability, will be the determining factor in remedying the situation.

European consumption is hardly likely to increase to such a point as to be a deciding factor—at least not for some time to come. Absorption of zinc by Europe in 1930 was far beyond what anyone expected, but some observers are inclined to believe that this was more apparent than real and was caused by the fact that some consumers, especially the rollers, preferred to keep their works employed by manufacturing in excess of their actual needs.

The tonnage of metal available for the European markets is greater than required, and, as the overseas plants are the cheaper producers, the necessary reduction in output, in order that the industry may be put on a sound footing, must be effected in Europe. Certainly during January it has been reported that four Continental smelters have decided to suspend operations, and this is decidedly a move in the right direction, but the example will have to be more widely followed before a state of equilibrium can be reached. Assuming that the trend in production continues downward, it may be the middle of the year before the zinc market can be expected to be on the road to convalescence.

The feature of the world production statistics for 1930 is the increase registered in output by Canada, Mexico, and Scandinavia, and, to a lesser extent, by Poland, Australia, and South Africa. The future of the zinc industry lies mainly in the hands of the efficient and up-to-date smelters. No cartel has yet been able to effect any really efficient measure of control, and during the past month the last faint hope of being able to resuscitate some sort of agreement among producers is reported to have been abandoned.

German producers are again raising the question of a tariff on the importation of zinc into Germany, which protection they contend is absolutely essential if the domestic industry is to survive. Lately, Upper Silesian zinc has been selling in Western Germany, in which district it is usually unable to compete with Belgian metal, owing to the substantially higher transport charge. This is, of course, incidental to the reduced Belgian production.

Evidence of the crisis through which even the lowest-cost producers are passing is at hand when a company of the magnitude of the Electrolytic Zinc Company of Australasia, Ltd., is compelled to pass its dividend. This producer appears to have been almost the last of the electrolytic plants to adopt the practice of debasing a portion of its output and selling same at a very small premium over the price of G.O.B., as it was not until November that the company set aside part of its output and debased it by the addition of 0.8 per cent of lead. Certain of the Broken Hill companies have not for some months past gone to the expense of recovering the zinc concentrates from the silver-lead-zinc ores being treated by selective flotation, and one company is employing this zincy residue for the purpose of stope filling.

Stocks of zinc increased from 71,700 metric tons at end of 1928 to 119,400 at end of 1929, and made a further leap to 228,700 tons at end of 1930. This would tend to show that overproduction last year was only 109,300 tons and that consumption in 1930 totaled 1,301,300 metric tons.

Production in 1930, in metric tons, compares with the previous year as follows:

	Metric Tons	
	1929	1930
United States	579,600	457,800
Canada	78,100	108,900
Mexico	15,100	30,700
Belgium	199,900	178,000
Poland	169,000	174,500
France	91,600	90,300
Germany	101,800	99,400
Great Britain	59,200	49,700
Holland	25,700	23,200
Italy	15,600	19,800
Spain	11,800	10,900
Czechoslovakia	12,400	12,500
Yugoslavia	7,300	7,000
Scandinavia	9,300	42,500
Russia	4,400	5,200
Japan	23,000	22,400
French Indo-China	5,800	3,500
Australia	50,800	56,000
Rhodesia	12,300	18,300
World total	1,470,700	1,410,600

The month of January witnessed another increase in stocks of zinc, the gain amounting to 22,000 metric tons. Stocks on the last day of January, 1931, are estimated as follows:

	Metric Tons
United States	131,700
Canada	27,000
Australia	19,000
Germany-Poland	25,500
Belgium	13,500
France	5,000
Great Britain	12,500
Other Europe	8,000
Far East	4,500
Elsewhere	4,000
Total	250,700

Higher Silver Tariff in India No Check to Consumption

Sir George Schuster, in introducing the Indian budget, stated that fear that the increase of two annas per ounce in the Indian silver duty might check consumption of silver in India is unfounded. According to a dispatch to the *Wall Street Journal*, the government of India cannot agree with the one-sided argument suggested by the United States silver producers that production should continue unrestricted, while the various governments which hold stocks should refrain from selling.

The whole world depends upon India as a consumer. In the five years ended March 31, 1930, India absorbed about 540,000,000 oz. of silver, and in the current year the absorption will be up to the five-year average of 108,000,000 oz. Against this total, the government of India, out of its own holdings, sold only about 90,000,000 oz. Yet India is expected to stand aside and keep its own home market free to absorb the production of mines in the United States and Mexico. This is clearly not acceptable, however anxious India is to help cooperate.

The government is convinced, Sir George Schuster pointed out, that the price of silver is part of a wider price movement, and it is doubted whether silver can be dealt with successfully in isolated fashion. Sir George believes that international co-operation is needed for stabilizing all non-ferrous metals.

On Feb. 28 the Indian government raised the import duty on silver two annas per ounce, establishing the rate at six annas, equivalent to about 14½c. per ounce. The previous rate of four annas had been in effect since March 1, 1930.

■

St. Joe Report Reflects Drop in Metal Prices

Net profit of St. Joseph Lead, largest producer of lead ore in the United States, reflected the severity of the drop in the price of lead in 1930. The operating profit dropped from $10,237,728 in 1929, to $4,649,290 in 1930, and net profit, after all charges, was only $1,509,991, compared with $7,466,003. Inasmuch as the company maintained its dividend payments during the year, the total assets show a shrinkage from $44,331,785 on Dec. 31, 1929, to $40,733,728 on Dec. 31, 1930. Current assets dropped from $10,360,614 to $8,907,335, despite an increase in metal inventories from $1,831,778 to $3,611,171.

Ore production showed a slight increase—from 5,750,412 short tons to 5,999,813—the result of increased activities at the company's New York zinc mines. The lead content of lead concentrates produced dropped from 178,181 tons to 177,935, and the zinc content of zinc concentrates increased from 35,115 to 50,064 tons.

Molybdenum Production Held at Good Level

Production of molybdenum ore in the United States during 1930, though slightly less than in 1929, was substantially greater than in 1928 or in any preceding year, according to data collected by the U. S. Bureau of Mines.

The production in 1930, as estimated from reports from the leading producers for eleven months' operation, amounted to approximately 6,167,000 lb. of molybdenum sulphide. Most of this material was represented by concentrates, although a small amount of high-grade ore was shipped from the mines without concentrating. Shipments of concentrate and ore from the mines contained an equivalent of approximately 3,700,000 lb. of elemental molybdenum, valued, more or less arbitrarily, at $2,000,000. Shipments in 1929 amounted to 3,904,648 lb.; in 1928 they were 3,329,214 lb.

Molybdenum stocks at the mines and reduction works increased relatively little and actual consumption was substantially larger in 1930 than during any previous year except 1929. Since by far the bulk of the production was used in steel manufacture, and since the production of steel dropped off 27 per cent last year, it is evident that the production of molybdenum-treated steels increased relatively to the total production of plain carbon and other alloy steels.

Molybdenum is used extensively in aircraft and automotive steels. To a smaller extent it is also used in various special steels employed in bearings, steel castings, and in corrosion and high-temperature resisting alloys for various purposes. A substantial outlet has recently been developed in the nickel-molybdenum-iron alloys containing as much as 20 per cent molybdenum and capable of resisting the action of hydrochloric acid. A surprising amount of molybdenum wire and sheet is used in the radio industry. Molybdenum wire, which is made by at least three companies, is used as the supporting filament in incandescent lamps and radio tubes. In the chemical field, a new development of importance is the use of various catalysts, several of which contain molybdenum oxide, in connection with the hydrogenation of oils and especially in the production of motor fuel from the heavier constituents of crude petroleum.

In April, 1930, the Molybdenum Corporation of America acquired the ferro-alloy and chemical plant and business of the York Metal & Alloy Company and subsequently has produced molyte and ferromolybdenum at its plant in Washington, Pa., and calcium molybdate, ammonium molybdate, sodium molybdate, molybdic oxide, and other chemicals at York, Pa. The capacity of the mine and mill of this company at Questa, N. M., was practically doubled as a results of the installation of a new power plant and the addition of new flotation cells. In Colorado, the Climax Molybdenum Company, the largest molybdenum producer in the world, completed its new crushing plant and is now in a position to supply from 7,000,000 to 8,000,000 lb. of the element annually, practically twice as much as the world has hitherto consumed in a single year. The new Phillipson tunnel, 465 ft. below the present working level, was continued through the Mosquito Fault into the mineralized area. This tunnel, which will be about 4,000 ft. long, should be completed early in 1931. The Pingrey Mines & Ore Reduction Company, which also owns claims near Climax, Colo., has taken steps to resume operations. Molybdenum prospects near Pitkin, Gunnison County, were being investigated by the Stone & Davis Corporation, and the Silver Queen Mining Company is prospecting near Rye, Custer County. New discoveries were reported in Nevada and in Alaska (near Wrangell).

■

Financial Notes

ERUPCION MINING, operating a lead property in Chihuahua, Mexico, reports a net loss of $38,781 in 1930, compared with $60,807 in 1929. Increase in production was responsible for the better showing. The company's balance sheet shows a deficit of $21,105.

AHUMADA LEAD, operating a lead property in the Los Lamentos district, Chihuahua, Mexico, reports a net loss of $153,240 in 1930, compared with a net loss of $28,067 in 1929. Lower metal prices and smaller production were responsible, the lead output being 9,487,548 lb., compared with 12,574,104 lb. in 1929. Current assets are put at $141,663, compared with liabilities of $16,209.

E.&M.J. Weighted Index of Non-Ferrous Metal Prices

100 Is Composite for 1922-3-4

1920	130.92
1921	80.80
1922	93.94
1923	103.43
1924	102.63
1925	111.74
1926	107.74
1927	97.54
1928	99.78
1929	110.33
1930	82.87

	1929	1930	1931
January	106.86	102.94	67.62
February	110.37	102.28	65.90
March	122.71	99.93	....
April	116.36	93.24	....
May	110.03	83.41	....
June	109.66	78.57	....
July	109.58	74.58	....
August	109.81	74.41	....
September	109.29	73.42	....
October	108.52	69.63	....
November	106.09	71.39	....
December	104.75	70.65	....

Silver King Coalition

Operating profit earned by Silver King Coalition Mines, Utah producer of lead, zinc, and silver, totaled $675,716 in 1930, compared with $2,038,654 in 1929. Although volume of production dropped only slightly (actually increasing in the case of zinc), the operating revenue from ore sales was only $2,403,773, compared with $4,088,419 in 1929. Net profit was $544,533 after payment of depreciation and administrative charges but before federal taxes. In 1929 it was $1,748,608. At the end of the year, the company's surplus was $2,692,852, compared with $2,927,899 at the beginning.

Production in 1930 was 155,950 short tons of ore, containing a total of 36,718,708 lb. of lead, 17,021,463 lb. of zinc, 2,250,871 oz. of silver, 1,262,370 lb. of copper, and 3,112 oz. of gold. Dividends paid during the year 1930 totaled $976,364.

Lead Production of the World

(American Bureau of Metal Statistics)

World production of lead, calculated on refined basis, and accredited so far as possible to countries of origin, in short tons, follows:

	1930						1931
	July	Aug.	Sept.	Oct.	Nov	Dec.	Jan.
United States	51 538	52 980	48,491	50,402	43,423	48,517	43,405
Canada	13,066	13,303	12,918	13,243	12,739	12,705	13,287
Mexico	22,661	22,563	21,583	23,308	23,167	26,854	23,979
Peru	1,261	1,070	1,084	1,077	385	.....	.....
Germany	9,140	11,235	11,322	9,604	10,918	10,959	10710
Italy	2,643	1,806	2,048	2,583	2,180	2,575	2,174
Spain and Tunis (a)	9,018	9,163	9,007	9.040	9,501	9,912	9,129
Europe, n.e.s. (b)	18,300	19,500	18,400	19,400	18,600	18,400	18,700
Australia	15,227	15,242	15,039	15,457	15,110	15,416	15,568
Burma	7,302	7,302	7,414	7,302	7,302	7,302	7 358
Elsewhere (b)	1,200	1,200	1,200	1,200	1,200	1,200	1,200
World totals	151,356	155,364	148,506	152,616	144,525	153,840	145,510
United States	51,538	52,980	48,491	50,402	43,423	48,517	43,405
Elsewhere	99,818	102,384	100,015	102,214	101,102	105,323	102,105

(a) Partial. (b) Estimated or partly estimated.

The daily rate of world production for January was 4,494 tons, against 4,963 tons in December, 1930, and 4,960 tons in January of last year.

Mining Company Dividends for February, 1931

Companies in the United States	Situation	Per Share	Total Disbursements
Alaska Juneau, g	Alaska	$0.10	$144,600
American Smelting & Refining	Various	1.00 Q	1,829,940
Anaconda Copper, c, z, l, s	Various	0.62½ Q	5,536,469
Bunker Hill & Sullivan, l, s	Idaho	0.25 M	81,750
East Butte, c	Montana	2.00 L	849,774
Freeport Texas Sulphur	Texas	1.00 Q	729,783
Homestake Mining, g	S. Dakota	0.50 M	125,580
Mohawk Mining, c	Michigan	0.25 Q	28,750
New Jersey Zinc	Various	0.50 Q	981,632
Vanadium Corp. of America	Various	0.75 Q	283,775
Companies in Other Countries			
Andes Copper	Chile	0.25 Q	773,333
Cerro de Pasco, c, s	Peru	0.50 Q	561,421
Granby Consolidated, c	Canada	0.50 Q	225,000
Hollinger Consolidated Gold	Canada	0.05 M	246,000
International Nickel, pfd., c, n	Canada	1.75 Q	158,959
Teck-Hughes, g	Canada	0.15 Q	713,574
Total			$13,270,340

c, copper; z, zinc; l, lead; s, silver; g, gold; n, nickel; Q, quarterly; M, monthly and extra: L, liquidating.

World Zinc Production Shows Drop for January

World zinc statistics for January, covering all countries except Belgium and Poland, revealed a moderate downward trend in production. Total output for all countries, excepting the two named, amounted to 83,602 tons, against 90,629 tons for the month of December.

Production statistics, in short tons, as compiled by the American Bureau of Metal Statistics, follow:

World Zinc Production

	Nov.	Dec.	Jan.
United States	32,097	32,682	32,522
Mexico	4,073	4,496	3,955
Canada	11,337	13,080	10,167
Belgium	(d)	(d)	(d)
France	7,717	8,301	8,000
Germany(a)	7,937	8,049	6,802
Great Britain	3,912	3,620	2,096
Italy	1,954	1,990	1,889
Netherlands	2,016	2,081	2,046
Poland(c)	17,161	17,564	(d)
Spain	1,005	969	982
Australia	5,006	5,161	5,137
Rhodesia	1,456	1,400	1,404
Elsewhere(b)	8,600	8,800	8,600
Totals	104,271	108,193	(e)83,602

(a) Includes zinc dust—about 300 tons per month. (b) Partly estimated. (c) Includes zinc dust. (d) Not reported. (e) Total not comparable with preceding months owing to omission of production statistics from Poland.

■

St. Mary's Mineral Land

Receipts from subsidiary companies, sales, interest, and rents of this holding company in the Michigan copper district were only $85,979 in 1930, compared with $800,076 in 1929. As a result, since dividends were continued, the company's cash surplus was reduced from $487,031 at the beginning of the year to $28,406 at the end. Failure of Champion Copper to distribute dividends was chiefly responsible for the drop. At the end of the year the company had total assets of $5,169,227.

■

Wright-Hargreaves Mines

Operating profit of Wright-Hargreaves Mines, gold producer of northern Ontario, was $1,117,484 in 1930, after depreciation charges. In 1929 it was $415,842. After addition of miscellaneous income, the net to surplus in 1930 was $1,186,004. Surplus account on Dec. 31, 1930, showed $1,323,211, compared with $808,470 at the beginning of the year. The company's total assets are put at $3,973,928, of which $2,199,958 are current assets. Bullion production in 1930 was $2,431,897, compared with $1,741,873 in 1929.

■

Consumption of All Metals in Germany Below Normal

Special Berlin Correspondence

The business outlook in Germany remains uncertain. Production in the metal-manufacturing plants continues far below normal and in quite a few instances the rate of operations is considerably less than 50 per cent of capacity. To stimulate export business, brass producers have agreed to continue the rebate of eight marks a hundred kilos for lots disposed of in foreign markets. At prevailing low prices, the drawback is felt more keenly than formerly.

Russia is about to establish a zinc smelter at Wladikawkas having a capacity of 20,000 tons a year. A lead mill with a capacity of 12,000 tons is also planned. Both plants will be completed this year, according to reports, and will involve an expenditure of 46,000,000 rubles.

The controversy between the German aluminum industry and the Swiss Neuhausen interests on the subject of import quotas has been settled. From present indications the European aluminum cartel will probably be revived. The Germany aluminum industry is operating at about 35 per cent of capacity. The demand for aluminum products continues slow, and stocks are accumulating.

Stocks of lead in Germany are being held down to a minimum because of the unfavorable market for lead products. Owing to the large world stocks, buyers see no cause for anxiety about obtaining ample supplies of lead when necessary.

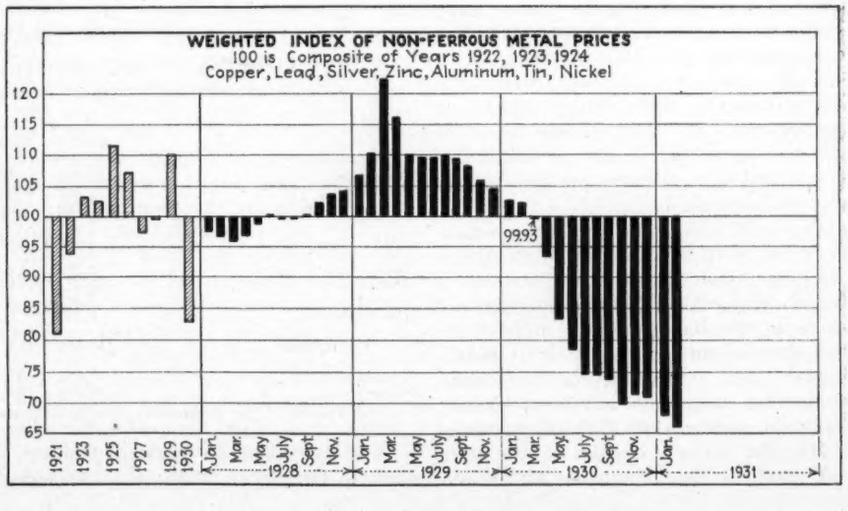
■

United Verde Extension

The drop in metal prices during 1930 cut United Verde Extension's gross revenue from production in half—$5,536,973, compared with $11,780,473 in 1929. As a consequence, operating profit dropped from $5,914,303 to $1,355,855, and a net profit of $2,988,898 in 1929 was turned into a net loss of $1,513,861 after depreciation and depletion charges. The company's total assets on Dec. 31, 1930, were put at $10,943,196, compared with $15,742,312 on Dec. 31, 1929. Production in 1930 was 40,817,814 lb. from company ores, compared with 59,067,913 lb. in 1929.

■

CUSI MEXICANA MINING, operating a silver-lead property in Chihuahua, Mexico, reports a net loss of $14,621 after all charges in 1930. Operating profit was $74,975, compared with $55,191 in 1929. The gross value of production was $594,476 after smelter and freight charges. Total assets are put at $3,472,682, of which $460,785 is surplus.



Copper Advanced to 10.50c., Delivered—Fair Trade in Lead and Zinc

New York, March 5, 1931.—Now that a balance between production and consumption of copper has been achieved, producers are taking a firmer view of the market. The price of copper was raised during the period to 10½c., delivered Connecticut, largely on the strength of the recent foreign buying and a moderate improvement in domestic business. A good tonnage of lead was sold at unchanged prices. At prevailing low levels, consumers of zinc took on a fair quantity for delivery over the next three months. The news of the favorable developments in regard to the tin agreement brought out a better tone in that commodity, though the net change in price for the week was insignificant. Silver has been firmer on moderate offerings. Platinum was reduced by the leading seller to $30 per ounce, a reduction of $4. Antimony and quicksilver were both slightly easier.

Copper Sales Improve

The domestic price of copper held at 10¼c., Connecticut basis, until Feb. 28, when a moderate tonnage sold at 10½c. By Monday, March 2, all sellers raised their quotations to the higher level, and the market was firm at the new price throughout the remainder of the week. The export price was advanced to 10.80c., c.i.f. European ports, on March 2, to conform with the higher domestic quotation.

The recent activity in the export market, together with a slow but steady increase in the movement of copper for domestic consumption, has strengthened the ideas of producers, who now feel that the trend of business will continue upward, even though the gains may be slight. Brass makers report larger shipments. Specifications for March shipment are coming through at a better rate, and in some quarters it is believed that the movement of brass during the current month will be largest since last July. Electrification by railroads is taking a fair tonnage of wire, but otherwise the demand for copper from the electrical industry remains backward.

Foreign business booked during February amounted to 60,000 long tons, an excellent showing contrasted with recent months. Export sales since the first of March have slowed down, owing to the advance in the price, the total for the four days amounting to a little more than 3,500 long tons.

Lead Steady

Demand for lead was fairly active in the two weeks that ended yesterday, and the tonnage sold was sufficient to make for a steady market. The upward trend in operations in the automotive field and some good orders for lead from corroders served to move a fairly large quantity. Returns for February indicate that sales of lead in that month were the largest since November. Actual shipments of virgin lead during February amounted to slightly more than 35,000 tons, which, considering the short month, reflects an increase in the daily movement of the metal into consumptive channels.

Advices from Australia, reproduced elsewhere in this issue, report that the Zinc Corporation has posted a notice to the effect that its plant will close on April 25. Cessation of operations at the Broken Hill property would reduce the Australian output of lead almost one-third.

The market for lead in New York held at 4.60c. throughout the period, the contract basis of the American Smelting & Refining Company, and at 4.35c., St. Louis.

World lead production for January totaled 145,510 tons, against 153,840 tons in the preceding month, and 155,452 tons in January, 1930.

Zinc Pressure Slackens

The market was a shade higher as the period came to a close, owing to the fact that certain sellers disposed of quite a liberal tonnage on the recent dip below the 4c. basis. Announcement of a reduction in output of concentrate in the Tri-State district was a factor in removing some of the selling pressure. Trading during the two weeks was fair, galvanizers and sheet mills showing moderate interest for April-May. Yesterday, virtually all sellers were asking 4.05c. for near-by metal.

Tin Unsettled

Despite the favorable developments in connection with the scheme to stabilize tin, traders attached quite some importance to the February statistics. The so-called world's visible supply of tin was augmented by 5,720 long tons, making the total at the end of the month 49,339 long tons. The gain in supplies was attributed to the scramble to bring out metal before the tin plan became effective. Buying here was quiet. The tin group supported the London market on any sign of weakness.

Silver Quiet

During the last two weeks the silver market remained quiet, with only small fluctuations in price. Business in the local market has been on a small scale against sales made to India for spot deliveries. The market closed firm on good inquiry and limited offerings.

Average Metal Prices for February, 1931

COPPER:	
Electrolytic, refinery	9.724
London Standard Spot	45.372
London Electrolytic, Bid	47.950
LEAD:	
New York	4.552
St. Louis	4.340
London Spot	13.444
London Forward	13.550
SILVER:	
New York	26.773
London	12.432
Sterling Exchange	485.551
ZINC:	
St. Louis	4.012
London Spot	12.303
London Forward	12.694
TIN:	
Straits	26.315
London Standard Spot	117.919
QUICKSILVER	100.205
ANTIMONY	7.069
PLATINUM, Refined	34.000
CADMIUM	55.000
ALUMINUM, 99 Per Cent Plus	23.300

Other Metals

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £85, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY — Per lb., duty paid, Chinese spot, 7c., futures, 6.90c. Cookson's "C" grade, spot, 12¼c. "C.M.C." grade, 99.9 per cent, spot, 10¾c.

BISMUTH—Per lb., $1.25. London, 5s., for lots of 500 lb. or more.

CADMIUM—Per lb., 55c. London, 1s. 9½d.@1s. 10½d.

IRIDIUM — Per oz., $160 for 98@99 per cent sponge and powder. London, £33@£35.

NICKEL — Per lb. electrolytic cathodes, 35c.; shot and ingot made from remelted electro, 36c., for single lots of spot metal. London, per long ton, £170 @£175, as to quantity.

PALLADIUM — Per oz., $19@$21. London, £3 15s. to £4 5s.

PLATINUM—Per oz., official price of leading interest was reduced from $34 to $30 on March 3. Cash transactions between dealers several dollars less. London quotes from £6 10s. to £6 15s., as to quantity.

QUICKSILVER—Per 76-lb. flask, $98@$100. Business moderate and prices unsettled. London reports the market unchanged at £22 7s. 6d. per flask.

Chromium, Cobalt, Magnesium, Manganese, Molybdenum, Osmium, Radium, Rhodium, Ruthenium, Selenium, Silicon.

Daily Prices of Metals

Feb. Mar.	Electrolytic Copper	Straits Tin	Lead		Zinc
	Refinery	New York	New York	St. Louis	St. Louis
19	10.025	27.125	4.60	4.35	3.95@4.00
20	10.025	27.125	4.60	4.35	3.925@4.00
21	10.025	26.75	4.60	4.35	3.95
23			Holiday		
24	10.025	27.20	4.60	4.35	3.95
25	10.025	27.15	4.60	4.35	3.95
Av'ge	10.025	27.070	4.600	4.350	3.958
26	10.025	27.00	4.60	4.35	4.00
27	10.025	27.00	4.60	4.35	4.00
28	10.025@10.275	26.90@27.00	4.60	4.35	4.00
2	10.275	27.25	4.60	4.35	4.05
3	10.275	26.75	4.60	4.35	4.05
4	10.275	26.75	4.60	4.35	4.05
Av'ge	10.171	26.950	4.600	4.350	4.025

Average metal prices for calendar week ended February 21, 1931, are: Copper: 9.921c.; Straits tin, 26.658c.; New York lead, 4.550c.; St. Louis lead, 4.325c.; Zinc, 3.981c.; Silver, 26.438c.

Average metal prices for calendar week ended February 28, 1931, are: Copper, 10.050c.; Straits tin, 27.060c.; New York lead, 4.600c.; St. Louis lead, 4.350c.; Zinc, 3.980c.; Silver, 27.000c.;

The above quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

In the trade, copper prices are quoted on a delivered basis; that is, delivered at consumer's plant. As delivery and interest charges vary with the destination, the figures shown above are net prices of refineries on the Atlantic seaboard. Delivered prices in New England average 0.225c. per pound above those quoted.

Quotations for copper are for the ordinary forms or wirebars and ingot bars. For ingots an extra 0.05c. per pound is charged; for slabs, 0.075c.; and for cakes, 0.125c. up, depending on weight. Cathodes are sold at a discount of 0.125c. per pound.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. The contract price for High-Grade zinc delivered in the East and Middle West is 1c. above the St. Louis price for Prime Western.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

Silver, Gold, and Sterling Exchange

Feb.	Sterling Exchange "Checks"	Silver		Gold, London	Feb. Mar.	Sterling Exchange "Checks"	Silver		Gold, London
		New York	London				New York	London	
19	4.85 7/16	27	12 7/16	84s 11½d	26	4.85½	26 7/8	12 7/16	84s 11½d
20	4.85¼	26¼	12 7/16	84s 11½d	27	4.85½	27	12½	84s 11½d
21	4.85¼	27¼	12 7/16	.....	28	4.85 5/8	27 3/8	12¾	.....
23	Holiday	Holiday	12¾	84s 11d	2	4.85½	27	12⅝	84s 11½d
24	4.85 5/8	27⅛	12 11/16	84s 11½d	3	4.85½	27	12⅝	84s 11½d
25	4.85¾	26⅝	12⅝	84s 11½d	4	4.85½	27⅝	12⅝	84s 10½d

Average for week ended February 25: Silver, 26.85c.; Sterling Exchange, $4.85463.
Average for week ended March 4: Silver 27.146c.; Sterling Exchange, $4.85521.

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, basis of 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command three-sixteenths cent premium.

London

Feb. Mar.	Copper Standard		Electrolytic (Bid)	Tin		Lead		Zinc	
	Spot	3 M		Spot	3 M	Spot	3M	Spot	3 M
19	47⅞	46 7/16	49¼	121¼	122¾	13⅞	14	12 13/16	13 1/16
20	46 13/16	46 13/16	49½	122¾	124¼	14 3/16	14¼	13⅛	13 5/16
23	47	47	49⅞	123	124½	13 15/16	14	12⅞	13 3/16
24	46¾	46 13/16	49¾	122⅝	123⅝	13 15/16	14	12¾	13 1/16
25	47⅜	47½	50¼	121⅝	122⅞	14⅜	14½	13⅛	13 7/16
26	46¾	46¾	49½	120¾	122¼	14	14⅛	12¾	13 1/16
27	46½	46 13/16	49½	121¾	123¼	13 15/16	14 1/16	12 11/16	13 1/16
2	47 3/16	47½	50¼	123	124½	14 5/16	14⅜	13	13 7/16
3	46 11/16	46 15/16	49¾	122⅝	123⅞	14⅛	14¼	12⅞	13⅜
4	46⅝	46 11/16	49⅝	121⅜	122⅞	14 3/16	14 5/16	12⅞	13 7/16

Prices for lead and zinc are the official prices for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

Tantalum, Tellurium, Thallium, and Tungsten are unchanged from prices given in the Feb. 23 issue.

Metallic Ores

Prices in tons of 2,000 lb., or in "Units" of 20 lb., unless otherwise stated.

CHROME ORE — Per long ton, c.i.f. Atlantic ports, Russian and Indian ores, 46 to 48 per cent CR_2O_3, $19.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty of 1c. per lb. of Mn contained, Indian, 48 to 50 per cent, 26@27c.; South African, 52 to 54 per cent, 25@26c. Caucasian, 52@55 per cent, 25@26c. per long ton unit.

TUNGSTEN ORE—Per unit of WO_3, New York: Chinese wolframite, duty paid, $11@$11.50. Bolivian scheelite, $11.50, domestic scheelite, $12.

Antimony, Beryllium, Iron, Molybdenum, Tantalum, Tin, Titanium, Vanadium, and Zircon ores are unchanged from prices given in the Feb. 23 issue.

Non-Metallic Minerals

Non-metallic mineral quotations are unchanged from those given in the issue of Feb. 23.

Refractories

Refractories are unchanged from the prices given in the Feb. 23 issue.

Alloys

Alloys are unchanged from prices given in the Feb. 23 issue.

Metallic Compounds

ARSENIOUS OXIDE (White arsenic)—Per lb., 4c., delivered, all positions.

COPPER SULPHATE (Blue Vitriol)—Per lb., in car lots, 4.25c. for either large or small crystals.

For prices on Calcium Molybdate, Cobalt Oxide, Germanium Dioxide, Sodium Nitrate, Sodium Sulphate, Zinc Oxide, and Zirconium Dioxide see issue of Feb. 23.

Rolled Metals

COPPER—Per lb., sheets, hot-rolled, 20⅜c.; wire, f.o.b. mill, 12¼c.

LEAD SHEETS—Per lb., full rolled, 7¾c.; clipped, 8c.

MONEL METAL—Per lb., sheets, full finished, 42c.; rods, hot-rolled, 35c.

MUNTZ METAL—Per lb., rods, 16¾c.; plates, 19⅝c.

NICKEL—Per lb., sheets, full finished, 52c.; rods, hot-rolled, 45c.

NICKEL SILVER—Per lb., sheets, 10 per cent, 25@25⅜c.; 18 per cent, 28½@28⅞c. Wire and rods, 10 per cent, 28½c.; 15 per cent, 32½c.; 18 per cent, 36c.

PHOSPHOR BRONZE—Per lb., sheets and rods, 5 per cent tin, 31⅝c.; wire, 5 per cent, 32¼c.; 10 per cent, 37⅝c.

ZINC SHEETS—Per lb., 9½c., f.o.b. works, ribbon, 9c.; 7 per cent discount on orders for 18 tons or more.

Metal Statistics

Monthly Average Prices of Metals

Silver

	New York		London Spot		Sterling Exchange	
	1930	1931	1930	1931	1930	1931
January	45.000	29.423	20.896	13.810	486.447	485.260
February	43.193	26.773	20.008	12.432	485.784	485.551
March	41.654	.....	19.298	.....	485.933	.....
April	42.428	.....	19.554	.....	486.019	.....
May	40.736	.....	18.850	.....	485.724	.....
June	34.595	.....	16.049	.....	485.625	.....
July	34.346	.....	15.928	.....	486.300	.....
August	35 192	.....	16.283	.....	486 839	.....
September	36 315	.....	16.738	.....	485.888	.....
October	35.846	.....	16.563	.....	485.719	.....
November	35.908	.....	16.625	.....	485.454	.....
December	32 635	.....	15.201	.....	485.413	.....
Year	38 154	.....	17.666	.....	485.929	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery		London Spot			
	Electrolytic		Standard		Electrolytic	
	1930	1931	1930	1931	1930	1931
January	17.775	9.838	71.469	44.938	83.250	47.524
February	17.775	9.724	71.419	45.372	83.500	47.950
March	17.775	.....	69.202	.....	83.405	.....
April	15.621	.....	62.075	.....	74.338	.....
May	12.756	.....	53.159	.....	59.545	.....
June	12.049	.....	50.003	.....	56.750	.....
July	11.023	.....	48.277	.....	52.522	.....
August	10.693	.....	47.525	.....	50.725	.....
September	10 310	.....	46 264	.....	49.500	.....
October	9.597	.....	43.030	.....	45.772	.....
November	10.113	.....	46.134	.....	48.963	.....
December	10.300	.....	46.771	.....	50.065	.....
Year	12.982	.....	54.611	.....	61.528	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1930	1931	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	6.250	4.802	6.100	4.604	21.545	21.571	13.872	13.905
February	6.236	4.552	6.086	4.340	21.188	21.097	13.444	13.550
March	5.662	.....	5.542	.....	18.807	18.940	.....	.....
April	5.537	.....	5.428	.....	18.319	18.363	.....	.....
May	5.523	.....	5.408	.....	17.795	17.861	.....	.....
June	5.410	.....	5.310	.....	17.941	17.994	.....	.....
July	5.250	.....	5.149	.....	18.160	18.063	.....	.....
August	5.488	.....	5.340	.....	18.294	18.178	.....	.....
September	5.500	.....	5.348	.....	17.909	17.798	.....	.....
October	5.151	.....	4.999	.....	15.747	15 674	.....	.....
November	5.100	.....	4.950	.....	15.934	15.931	.....	.....
December	5.100	.....	4.950	.....	15.283	15.292	.....	.....
Year	5.517	.....	5.384	.....	18.077	18.064	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin and Cadmium

	New York		London		Cadmium
	1930	1931	1930	1931	1931
	Straits		Spot		
January	38.851	26.137	175.460	115.798	67.115
February	38.676	26.315	173.750	117.919	55.000
March	36.798	.....	164.851	.....	.....
April	36.077	.....	162.638	.....	.....
May	32.108	.....	144.818	.....	.....
June	30.336	.....	136.300	.....	.....
July	29.822	.....	134.511	.....	.....
August	30.044	.....	134.988	.....	.....
September	29.647	.....	132.631	.....	.....
October	26.802	.....	117.451	.....	.....
November	25.904	.....	113.519	.....	.....
December	25.262	.....	111.560	.....	.....
Year	31.694	.....	141.873	.....	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St Louis		London			
	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	5.229	4.035	19.634	20.241	12.747	13.113
February	5.180	4.012	19.209	19.778	12.303	12.694
March	4.934	.....	18.304	18.810	.....	.....
April	4.843	.....	17.819	18.378	.....	.....
May	4.641	.....	16.639	17.330	.....	.....
June	4.441	.....	16.422	17.038	.....	.....
July	4.350	.....	16.171	16.777	.....	.....
August	4.360	.....	15.953	16.469	.....	.....
September	4.270	.....	15.773	16.080	.....	.....
October	4.059	.....	14.446	14.935	.....	.....
November	4.266	.....	14.706	15.238	.....	.....
December	4.099	.....	13.762	14.214	.....	.....
Year	4.556	.....	16.570	17.107	.....	.....

St. Louis quotations, cents per pound. London pounds sterling per long ton

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1930	1931	1930	1931	1930	1931
January	8.606	7.317	121.192	103.000	61.923	36.000
February	8.830	7.069	120.500	100.205	59.909	34.000
March	8.236	.....	118.808	.....	54.769	.....
April	7.740	.....	114.000	.....	46.462	.....
May	7.454	.....	117.269	.....	46.000	.....
June	7.057	.....	118.600	.....	46.000	.....
July	6.976	.....	117.462	.....	43.692	.....
August	7.839	.....	116.000	.....	41.462	.....
September	7.773	.....	113.620	.....	36.080	.....
October	7.288	.....	110 596	.....	36.000	.....
November	7.105	.....	106.717	.....	36.000	.....
December	7.099	.....	105.346	.....	36.000	.....
Year	7.667	.....	115.009	.....	45.358	.....

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce.

Pig Iron[1] and Aluminum

	Bessemer		Basic		No. 2 Foundry		Aluminum	
	1930	1931	1930	1931	1930	1931	1930	1931
Jan	19.00	17.50	18.50	17.00	18.50	17.00	24.300	23.300
Feb	19.00	17.29	18 50	16.79	18.50	16.79	24.300	23.300
March	19.00	.....	18 50	.....	18 50	.....	24.300	.....
April	19.00	.....	18.50	.....	18.50	.....	24.300	.....
May	19.00	.....	18.50	.....	18.50	.....	24.300	.....
June	19 00	.....	18 50	.....	18.50	.....	24.140	.....
July	18.62	.....	18 12	.....	18.12	.....	23.300	.....
Aug	18.50	.....	18 00	.....	18 00	.....	23.300	.....
Sept	18.38	.....	17 76	.....	17 88	.....	23.300	.....
Oct	17.85	.....	17 00	.....	17.22	.....	23.300	.....
Nov	17.50	.....	17.00	.....	17.00	.....	23.300	.....
Dec	17 50	.....	17 00	.....	17.00	.....	23.300	.....
Year	18.53	.....	17 99	.....	18.02	.....	23.787	.....

Iron in dollars per long ton. Aluminum in cents per pound, 99 per cent grade.

[1]F.o.b. Mahoning and Shenango valley furnaces; freight to Pittsburgh, $1.76.

Monthly Crude Copper Output in Short Tons

Domestic

	1929 Total	1930 Total	1930 Sept.	1930 Oct.	1930 Nov.	1930 Dec.
Alaska shipments	21,947	18,953	2,223	2,438	1,883	1,817
Calumet & Arizona	65,246	45,161	3,730	3,836	3,608	3,166
Magma	19,118	15,940	1,577	1,623	1,940	1,203
Miami	29,567	34,568	2,701	2,798	2,657	2,611
Nevada Cons	133,140	70,990	(d) 16,686	.....	.....	(d) 16,583
Old Dominion (a)	11,172	10,428	756	781	824	879
Phelps Dodge (b)	111,026	72,308	6,014	6,015	5,718	5,151
United Verde Extens	29,669	21,908	1,886	1,702	1,504	1,236
Tennessee Copper	7,870	7,772	597	656	667	646

Foreign

Andes Copper	83,718	.....	3,941	3,936	3,749	.....
Braden	88,155	.....	8,212	10,299	9,058	.....
Boleo, Mexico	12,898	13,940	(d) 3,537	.....	.....	(d) 3,288
Bwana M'Kubwa	6,988	.....	617	571	497	404
Chile	150,247	.....	7,486	7,480	7,118	.....
Furukawa, Japan	17,767	.....	1,642	1,611	1,432	.....
Granby Cons., Canada	30,424	.....	2,333	1,882	1,771	1,595
Howe Sound	21,516	22,633	(d) 5,828	.....	.....	(d) 5,231
Messina	(c) 7,200	.....	824	780	826	896
Mt. Lyell	9,731	10,878	(d) 3,249	.....	.....	(d) 2,504
Sumitomo, Japan	20,180	.....	1,110	2,202	1,554	1,367

(a) Includes Arizona Commercial. (b) Moctezuma is included. (c) Estimated. (d) Three months.

Monthly Production of Primary Copper from U. S. Mines and Daily Rate (Short Tons)

	1928		1929		1930	
	Monthly Production	Daily Rate	Monthly Production	Daily Rate	Monthly Production	Daily Rate
January	68,469	2,209	86,324	2,785	67,838	2,188
February	67,423	2,352	84,735	3,026	59,196	2,114
March	70,327	2,269	93,698	3,023	61,216	1,975
April	69,721	2,324	94,902	3,163	60,450	2,015
May	73,729	2,378	93,392	3,013	60,238	1,943
June	73,224	2,441	82,354	2,745	56,743	1,891
July	73,426	2,369	79,229	2,556	54,249	1,750
August	76,952	2,482	78,885	2,545	56,779	1,832
September	78,341	2,611	79,402	2,647	56,584	1,886
October	86,480	2,790	82,575	2,664	55,954	1,805
November	85,382	2,846	75,934	2,531	53,141	1,771
December	85,677	2,764	74,772	2,412	48,518	1,565
Total	909,051	.....	1,006,203	.....	690,263	.....
Monthly average	75,754	.....	83,850	.....	57,522	.....
Av. of daily rate	.....	2,484	.....	2,757	.....	1,891

Mining Share Prices—Month of February, 1931

Company Name	High	Low	Last	§Most Recent Dividend	
NEW YORK STOCK EXCHANGE					
Ahumada Lead	0.87½	0.37½	0.75	April, 1927	0.12½
Alaska Juneau	9.62½	8.25	8.37½	Ja. 10, Fe. 1, 1931 QI	0.10
American Metal	23¾	17	20½	December, 1930 Q	0.25
Am. Metal, pfd	89½	89	89	Fe. 17, Mh. 2, 1931 Q	1.50
Am. Sm. & Ref	58½	43¼	56¾	Ja. 16, Fe. 2, 1931 Q	1.00
Am. Sm. & Ref. 2nd pfd.	100½	99¼	100¼	Ja. 30, Mh. 2, 1931 Q	1.50
Am. Sm. & Ref., pfd	134½	130	134¼	Ja. 30, Mh. 2, 1931 Q	1.75
Am. Zinc, L. & S	8.75	4.50	7.75	May, 1917	1.00
Am. Zinc, L. & S., pfd.	39½	29	39½	Se. 22, Oc. 1, 1930 Q	1.50½
Anaconda	43½	32½	42	Ja. 10, Fe. 16, 1931 Q	0.62½
Andes Copper	19½	14	19½	Ja. 10, Fe. 9, 1931 Q	0.25
Butte C. & Z	2.00	1.62½	2.00	De. 10, De. 25, 1929	0.50
Butte & Superior	1.75	1.12½	1.12½	De. 13, De. 31, 1929 Q	0.50
Callahan Zinc-Lead	1.25	0.62½	1.12½	December, 1920	0.50
Cal. & Arizona	42½	36½	41½	June, 1930	0.50
Cal. & Hecla	11½	8.62½	10½	June, 1930	0.50
Cerro de Pasco	30½	22½	28	Ja. 15, Fe. 2, 1931 Q	0.50
Dome Mines	11½	10½	10½	De. 31, Ja. 20, 1931 Q	0.25
Federal M. & S	80	80	80	June, 1927	10.00
Federal M. & S., pfd	94	94	94	No. 25, De. 15, 1930 Q	1.75
Freeport Texas	42	32	37½	Ja. 15, Fe. 1, 1931 Q	1.00
Granby Con	22½	15½	20½	Ja. 16, Fe. 2, 1931 Q	0.50
Greene Cananea	....	....	46*	July, 1930	0.75
Homestake	88	83	85	Fe. 20, Fe. 25, 1931 M	0.50
Howe Sound	29½	22½	29	De. 31, Ja. 15, 1931 Q	1.00
Inspiration	11½	7.62½	10½	July, 1930	0.50
International Nickel	20½	13½	19	Mh. 2, Mh. 31, 1931 Q	0.15
Int. Nickel, pfd	120½	116½	120½	Ja. 3, Fe. 2, 1931 Q	1.75
Kennecott	31½	23½	30½	De. 5, Ja. 2, 1931 Q	0.50
McIntyre-Porcupine	22½	21½	21½	Fe. 2, Mh. 2, 1931 Q	0.25
Magma Copper	27½	20½	26½	De. 31, Ja. 15, 1931 Q	0.75
Miami Copper	10½	7.50	10½	August, 1930	0.375
Mother Lode	0.75	0.50	0.62½	June, 1930	0.10
National Lead	130½	120½	127½	De. 12, De. 31, 1930 Q	1.25
National Lead, pfd. A	140½	140	140	No. 28, De. 15, 1930 Q	1.75
National Lead, pfd. B	119½	118	119½	Ja. 16, Ja. 31, 1931 Q	1.50
Nevada Con	14½	10½	14	De. 12, De. 31, 1930 Q	0.25
Park Utah Con	1.75	1.37½	1.75	Je. 14, Jl. 10, 1929 Q	0.20
Patiño M. & E	15½	10½	14	December, 1929	4s.
Phelps Dodge	20½	20½	24	De. 13, Ja. 2, 1931 Q	0.50
Rand Mines	....	....	27½*	August, 1930	1.52
St. Joseph Lead	30½	25	28½	Mh. 10, Mh. 20, 1931 Q	0.50
Seneca Copper	1.75	1.12½	1.75	....	....
Tennessee Corp	9.50	8.50	9.00	No. 29, De. 15, 1930 Q	0.25
Texas Gulf Sulphur	55½	48½	55	De. 1, De. 15, 1930 Q	1.00
U. S. S. R. & M	23¾	18½	22½	De. 31, Ja. 15, 1931 Q	0.25
U. S. S. R. & M., pfd	46	44	44½	De. 31, Ja. 15, 1931 Q	0.875
Utah Copper	124½	100	117½	De. 12, De. 31, 1930 Q	2.00
Vanadium Corp	75½	48½	66½	Fe. 2, Fe. 16, 1931 Q	0.75
NEW YORK CURB EXCHANGE					
Aluminum Co. of Am.	178	145½	162	....	....
Alum. Co. of Am., pfd.	109½	108½	109	De. 15, Ja. 1, 1931 Q	1.50
Anglo-Chilean Con	14½	9.87½	13	....	....
Bunker H. & S	53	45	53	Ja. 22, Fe. 5, 1931 M	0.25
Carnegie Metals	....	....	2.00*	....	....
Con. Coppermines	3.37½	2.50	3.00	....	....
Copper Range	....	....	7.75*	July, 1930	0.25
Cressen Con	0.50	0.37½	0.50	April, 1930	0.02
Cusi Mexicana	0.75	0.37½	0.56½	....	....
Evans-Wallower	3.25	1.00	2.50	....	....
Federated Metals	....	....	10½*	Ja. 5, Ja. 15, 1931 Q	0.25
Hecla Mining	7.50	5.50	6.75	No. 15, De. 15, 1930 Q	0.25
Hollinger Con	8.50	7.75	7.75	Fe. 11, Fe. 25, 1931 M	0.05
Hudson Bay M. & S	5.87½	4.25	5.50	....	....
Iron Cap Copper	1.00	0.75	1.00	....	....
Mayflower Associates	45	42	45	De. 3 De. 15, 1930 Q	0.50
Mining Corporation	2.25	1.87½	2.12½	De. 4, De. 19, 1929	0.12½
New Jersey Zinc	49	47½	48½	Ja. 20, Fe. 10, 1931 Q	0.50
Newmont Mining	58½	48	56	De. 31, Ja. 15, 1931 Q	1.00
N. Y. and Honduras	11	10½	10½	Ja. 20, Ja. 31, 1931 QX	0.50
Nipissing	1.62½	.125	1.50	De. 31, Ja. 20, 1931 Q	0.075
Noranda Mines	18½	16½	18	October, 1930	0.50
Ohio Copper	0.50	0.25	0.50	September, 1926	0.03
Premier Gold	0.75	0.68¾	0.75	De. 12, Ja. 3, 1931 Q	0.03
Quincy	....	....	6.00*	March, 1920	1.00
Shattuck Denn	5.12½	4.50	5.00	....	....
So. Am. Gold & Plat	1.50	1.12½	1.37½	....	....
Teck-Hughes	7.12½	6.87½	6.87½	Ja. 17, Fe. 1, 1931 Q	0.15
Tonopah Mining	....	....	0.37½	Se. 30, Oc. 21, 1929	0.07½
United Eastern	....	....	0.06½	....	....
United Verde Ex	11	9.00	10½	Ja. 2, Ja. 31, 1931 Q	0.50
Utah-Apex	1.12½	1.12½	1.12½	De. 15, No. 1, 1929	0.025
Yukon Gold	0.12½	0.12½	0.12½	June, 1918	0.02
BOSTON STOCK EXCHANGE					
Ariz. Commercial	1.62½	0.65	0.65	Fe. 21, Fe. 28, 1931 IL	1.00
East Butte	2.00	0.07	0.15	Fe. 16, Mh. 4, 1931 L	2.00
Isle Royale	6.50	4.6 ¼	6.25	March, 1930	0.50
Mohawk Mining	21	16	19½	Ja. 31, Fe. 28, 1931 Q	0.25
Old Dominion	3.75	3.00	3.75	December, 1918	1.00
Utah Met. & Tunnel	0.56½	0.25	0.56	December, 1927	0.30
MONTREAL					
Asbestos Corp	0.50	0.25	0.25	January, 1926	1.50
Asbestos Corp., pfd	1.00	1.00	1.00	January, 1930	1.75
Consolidated M. & S	183	134	180	De. 30, Ja. 15, 1931 SAX	6.25

Company Name	High	Low	Last	§Most Recent Dividend	
SPOKANE					
Constitution	0.08½	0.06½	0.08½	....	....
Dayrock	1.30	1.20	1.25	March, 1930	0.03
Golconda	0.45	0.33	0.44	July, 1929	0.02
Jack Waite Con	0.45	0.32	0.43½	....	....
Los Lugos	0.03½	0.02	0.03½	....	....
Mexican Premier	0.17½	0.13½	0.17	January, 1930	0.01
Montana Mines	0.18	0.13½	0.16	....	....
Noble Five	0.08	0.03½	0.06	January, 1930	0.005
Pend Orielle	1.45	0.76	1.15	....	....
Sherman Lead	0.49	0.40	0.45	March, 1930	0.01
Sidney	0.11	0.08	0.11	October, 1929	0.01
Sunshine Mining	1.45	1.02	1.28	December 20, 1930 Q	0.03
Tamarack & Custer	0.30	0.27	0.28½	September, 1924	0.25
SALT LAKE CITY					
Chief Con	0.76	0.56	0.70	February, 1928	0.10
Combined Metals	0.09½	0.09	0.09½	....	....
Eureka Bullion	0.25	0.19	0.20	....	....
Eureka Lilly	0.23	0.18	0.19½	....	....
Moscow Silver	0.56	0.35	0.51	....	....
New Quincy	0.08½	0.03	0.05½	Se. 20, Se. 30, 1929 Q	0.10
North Lily	1.15	0.90	1.05	January, 1930	0.15
Park Bingham	1.25	0.75	1.25	....	....
Park City Con	0.24	0.20	0.23	....	....
Rico Argentine	0.03	0.03	0.03	December, 1929	0.03
Silver King Coal	5.60	5.05	5.35	De. 20, Ja. 2, 1931 Q	0.15
Tintic Lead	1.22½	1.00	1.15	....	....
Tintic Standard	4.07½	3.75	3.95	De. 13, De. 24, 1930 Q	0.20
Walker Mining	2.00	1.67½	2.00	April, 1930	0.075
TORONTO					
Abana Mines	0.20	0.13½	0.15	....	....
Amulet Mines	0.38	0.32	0.38	....	....
Base Metals	0.16	0.14	0.15¾	....	....
Barry-Hollinger	1.45	1.00	1.25	....	....
Canam Metals	0.05	0.04	0.04	....	....
Castle-Trethewey	0.19	0.15	0.19	....	....
Central Manitoba	0.10½	0.07½	0.09	....	....
Falconbridge	1.66	1.50	1.60	....	....
Howey Mines	0.36	0.28	0.28	....	....
Keeley	0.27	0.27	0.27	March, 1928	0.04
Kirkland Lake	0.74	0.63	0.63	....	....
Lake Shore	26 9/10	25½	25¾	De. 1, De. 15, 1930 Q	0.30
Sherritt-Gordon	1.25	0.88	1.17	....	....
Siscoe Gold	0.49	0.40½	0.46	....	....
Sylvanite	0.71	0.58	0.60	De. 5, De. 20, 1930 SA	0.02
Treadwell-Yukon	2.65	2.25	2.50	....	....
Ventures	0.62	0.47½	0.55½	....	....
Vipond Con	1.15	1.04	1.05	April, 1927	0.03
Waite A.-M	1.95	1.70	1.72	....	....
Wright-Hargreaves	2.28	2.15	2.18	No. 29, Ja. 2, 1931 Q	0.05
ST. LOUIS, CINCINNATI, AND DENVER					
Consolidated L. & Z	2.25	1.50	2.00	December, 1929	0.125
Eagle-Picher	5.50	5.00	5.12½	April, 1930	0.20
Eagle-Picher, pfd	....	....	100*	De. 31, Ja. 15, 1931 Q	1.50
Empire Chief	0.02	0.01½	0.01½	....	....
Star of Utah	0.59	0.55	0.57	....	....
Tungsten Prod	0.20	0.15	0.20	....	....
West Gold	0.03	0.01½	0.02¾	....	....
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS					
California Copper	0.75	0.50	0.50	....	....
(a) Golden Cycle	14½	13½	14	Fe. 28, Mh. 10, 1931 Q	0.40
Idaho-Maryland	0.72	0.36	0.65	....	....
(a) Portland	0.09½	0.07½	0.09½	April, 1927	0.01
Tom Reed	1.05	0.67	0.90	December, 1926	0.02
(a) United Gold	....	....	0.007½*	February, 1930	0.01

‡LONDON

Company Name	High	Low	Last	Most Recent Dividend (Per Cent, unless noted)
Anglo American	15/9	12/9	15/–	22½, Feb. 19, 1930
Aramayo Mines	21/3	19/6	21/3	5, Oct. 23, 1929
Burma Corporation	8/7½	7/9	8/7½	1¼, Dec. 10, 1930(b)
Bwana M'Kubwa	6/9	4/9	6/–	....
Camp Bird	7½d	5d	6d	16¼, April 25, 1928
(a) Fresnillo	8/3	8/3	8/3	25 cents, Feb. 12, 1930
Frontino & Bolivia	9/4½	8/1½	8/9	3¾, January, 1929
Lake View & Star	11/9	9/–	9/6	11½, 1921
Mexican Corporation	3/10½	3/–	3/9	10, Oct. 24, 1929
Oroville Dredging	2/–	1/9	2/–	37½, May 16, 1930
Rhodes, Congo Border	150/–	115/–	140/–	....
Rhodes-Select. Trust	20/–	17/6	18/1½	....
Rio Tinto	400/–	346/–	361/6	10, Nov. 21, 1930
St. John del Rey	19/10½	18/1½	19/6	3½, Nov. 21, 1930
San Francisco Mines	13/6	....	12/9	10, Jan. 7, 1931
Santa Gertrudis	8/6	6/10½	7/3	7½, Jan. 8, 1931
Selukwe	3/4½	2/–	2/10½	6¼, April 2, 1917
So. American Copper	3/–	1/9	2/10½	....
Tanganyika	36/6	26/–	35/–	2½, Aug. 2, 1930
Wiluna Gold	17/9	14/4½	15/6	....
Union Minière	6,600	5,775	6,485†	300 francs, July, 1930

Salt Lake Stock Exchange courtesy J. A. Hogle & Company, Spokane Standard Exchange courtesy the Pohlman Investment Company. *Not traded in. †Belgian Francs. ‡The above London quotations are for the month ended Feb. 20. Q, quarterly; I, initial; M, monthly; X, extra; SA, semi-annual; L, liquidating. §Total dividends paid during the month will be found tabulated in the Market and Financial News Section. (a) Bid prices. (b) 1¼% (2 annas) dividend, and bonus of ¾% (1 anna).